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HS/K-1037/PK/48.0/R0

Return to Sheila Thore

Safety Analysis Report Update Program

# Phase I Hazard Screening Analysis for Building K-1037 Barrier Process Plant

March 1992


Prepared by
Plant Safety Evaluation Team
OAK RIDGE K-25 SITE
Oak Ridge, Tennessee 37831
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
Oak Ridge, Tennessee
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400




**CAUTION**

This report contains preliminary information and was prepared primarily for use by participants in the SARUP program. Because the information is subject to revision, it should not be disseminated beyond the recipient organization. Also, documents prepared for public availability should not reference this report.

# PHASE I HAZARD SCREENING ANALYSIS FOR BUILDING K-1037 BARRIER PROCESS PLANT

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# PHASE I HAZARD SCREENING ANALYSIS FOR BUILDING K-1037 BARRIER PROCESS PLANT

## HAZARDS

| HAZARD | HAZARD CLASS |
|---|---|
| Nickel Powder | Negligible |

K-1037 Facility (Site Facility Operations Portion)
Hazard Classification is "Generally Accepted[αβγ]."
K-1037-C Facility Hazard Screening Classification is "Generally Accepted[αβγ]."

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Date

M Lomer
for L. E. Hall
K-25 Site Plant Manager
K-25 Site PSET Chairman

3/12/92
Date

[αβγ]Facility is radioactively contaminated, controlled in accordance with DOE Order 5480.11.

# PREPARATION AND REVIEW FOR BUILDING K-1037 BARRIER PROCESS PLANT

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# FIGURES

# 1. INTRODUCTION

Department of Energy (DOE) DOE/OR-901[1] requires that a safety review be performed and safety documentation be prepared for all DOE activities where DOE has assumed responsibility for safety. It has been recognized that existing safety documentation at the Martin Marietta Energy Systems, Inc. facilities does not meet current DOE guidance implementing DOE/OR-901. To address this concern, Energy Systems has developed a formal program for the systematic review and update of the existing Safety Analysis Report (SAR) at the Oak Ridge K-25 Site.[2] The SAR Update Program consists of the following four phases:

- Phase 0 - Continued Operation Evaluations,
- Phase I - Hazard Classification and Qualitative Analysis,
- Phase II - Quantitative Accident Analysis, and
- Phase III - Complete DOE-Approved SARs.

As part of the Phase I effort, Energy Systems has performed a hazard screening (HS) and qualitative analysis for selected facilities. This task is performed using input from the Facility Safety Evaluation Teams (FSET) in the form of the Preliminary Hazard Screening (PHS) Work Sheets. The facilities that potentially could pose significant safety hazards may be quantitatively, as well as qualitatively, analyzed to determine the extent and severity of the hazard.[3-7]

This report documents the hazards associated with the portion of Building K-1037 which has been assigned to Site Facility Operations including K-1037-C, Smelter House (Fig. 1.1). The production equipment was shut down and placed in standby in 1987. Building K-1037 is a multi-use facility that currently houses Atomic Vapor Laser Isotope Separation (AVLIS), and offices for Toxic Substances Control Act (TSCA), Pond Waste Management, Central Waste Management, Data Systems Research & Development, and Integrated Data Base personnel. The office wing is on the east end of the building. The Site Facility Operations and AVLIS Divisions are responsible for this facility.

The following activities are in progress or scheduled in the part of the K-1037 Building assigned to Site Facility Operations to further reduce potential hazards:[8]

- repair of Building K-1037 Barrier Process Plant's roof to prevent dispersion of toxic and radioactive contaminants by roof leaks;
- maintenance of fire protection system support; and
- conduct of the asbestos abatement program.

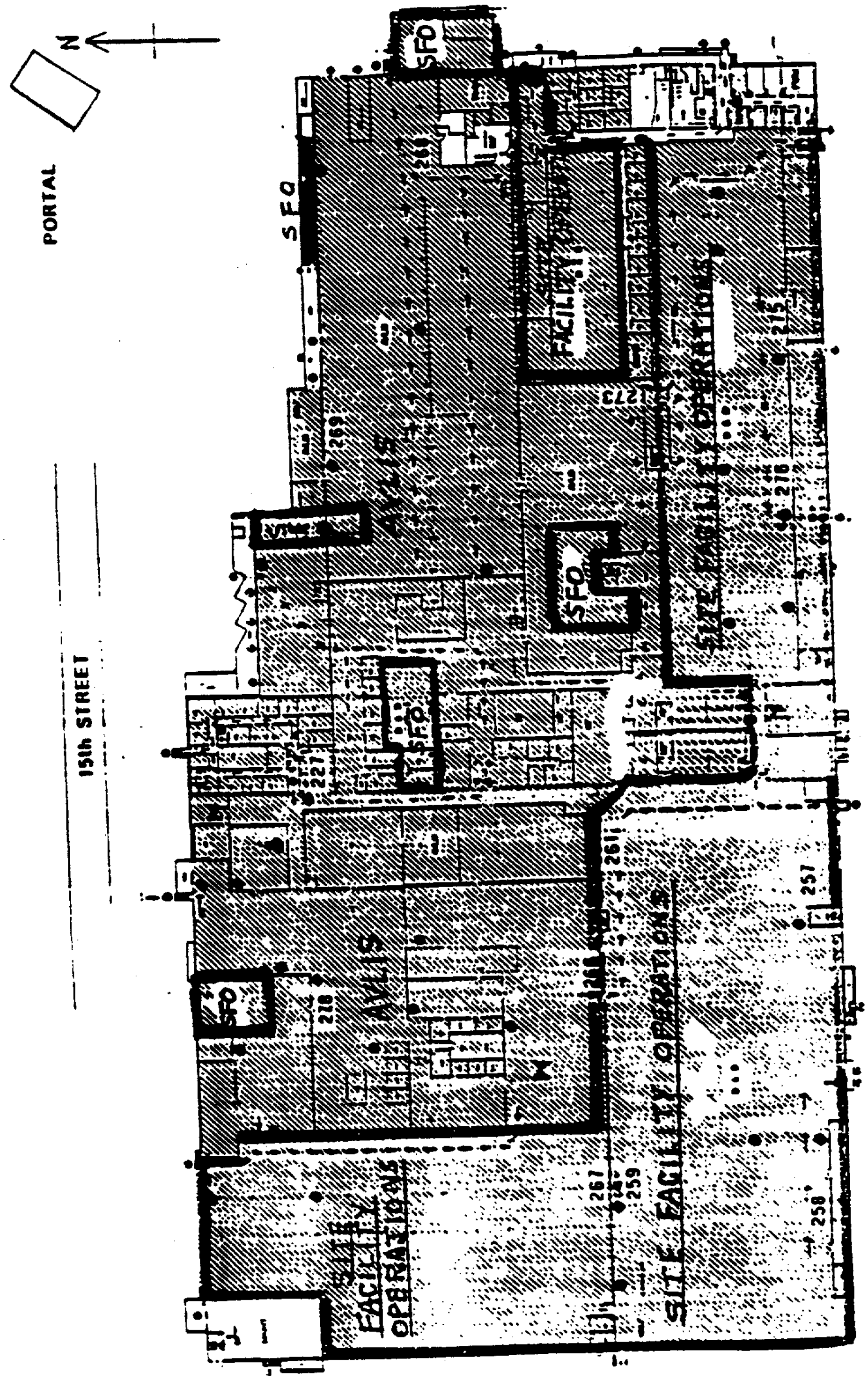



Fig. 1.1. Building K-1037 first floor.

# 2. SUMMARY

## 2.1 EVALUATION

The hazards evaluated in Site Facility Operations portion of Building K-1037 are categorized as follows:

- Special Nuclear Material
- Radiation Sources
    - surface contamination
- Toxic/Corrosive/Reactive Materials
    - nickel powder
- Electrical Energy
    - 13.8 kV transformers

In addition, the following hazards were identified in Building K-1037 but were screened out in the PHS, as approved by Plant Safety Evaluation Team:

- Explosives
    - natural gas lines purged on deactivated systems

It should be noted that a preliminary hazard assessment has been completed for the AVLIS Program and is, therefore, outside the scope of this assessment.

## 2.2 CONCLUSION

This report systematically evaluates the Building K-1037 hazards above. Based on the consequences associated with the dispersion of toxic nickel powder, the recommended hazard classification for this section of Building K-1037, including K-1037-C, is "Generally Accepted[safety]."

## 2.3 RECOMMENDATION

No further safety analysis is required for Building K-1037.

# 3. FACILITY DESCRIPTION

The K-1037 facility is a multi-use facility involving several divisions that currently houses offices, process areas, mock-up areas, and storage areas for equipment and materials from previous K-1037 programs. Site Facility Operations has been assigned the surveillance and maintenance responsibility for the major (approximately 60 percent) portion of the facility.

Building K-1037 is a steel-framed structure with reinforced concrete floors covering approximately 308,800 ft$^2$. The building complex is comprised of a series of buildings and additions that were constructed at separate times during the past 45 years and joined together under one roof. The original structure was a warehouse. The north bay is 65 ft wide, and the south bay is 55 ft wide. Each bay has a 15-ton bridge crane. The building is approximately 820 ft $\times$ 400 ft.

Transite siding covers the three outside walls of the eastern half of the building. Three outer walls of the western half of the structure are covered with metal siding. The building has three types of roof: a transite roof partially covered with aluminum; a sloped, metal roof; and a shallow, sloped, tar and chip roof. These three sections of roof coincide with the original building erected in 1945 and the two expansions that occurred in 1950 and about 1970. The roof has deteriorated since the plant was shut down and is currently being replaced.

The K-1037 building fire protection system consist of a wet pipe, fuse-link head, automatic sprinkler system. The sprinkler heads are spaced approximately 10 ft apart under the roof of the high-bay area and under the main operating platform. The links are designed to melt at 165°F. Activation of a pull box or the opening of a sprinkler head triggers audio-visual alarms locally and at Fire Department headquarters.

## 3.1 FACILITY LOCATION

The K-1037 building is located in the eastern part of the K-25 Site between the K-1435 TSCA Incinerator and the K-1501 Steam Plant (Fig. 3.1.) Building K-1037 is approximately 275 m from Blair Road at the nearest point, which would be the closest public access. The elevation of K-1037 is 788 ft above sea level.

## 3.2 FACILITY LAYOUT

The AVLIS Program is presently utilizing 40 percent of the building, predominantly in the north and northeast portion of the facility. Operation of K-1037, assigned to Site Facility Operations, is located in the central portion of the building and the remaining groups are to the south.

Adjacent to the west end of the facility is a single-story wing which includes the break area, offices, and storage areas. The wing has a partial basement that houses two indoor electrical substations, air compressors, and furnace transformers.

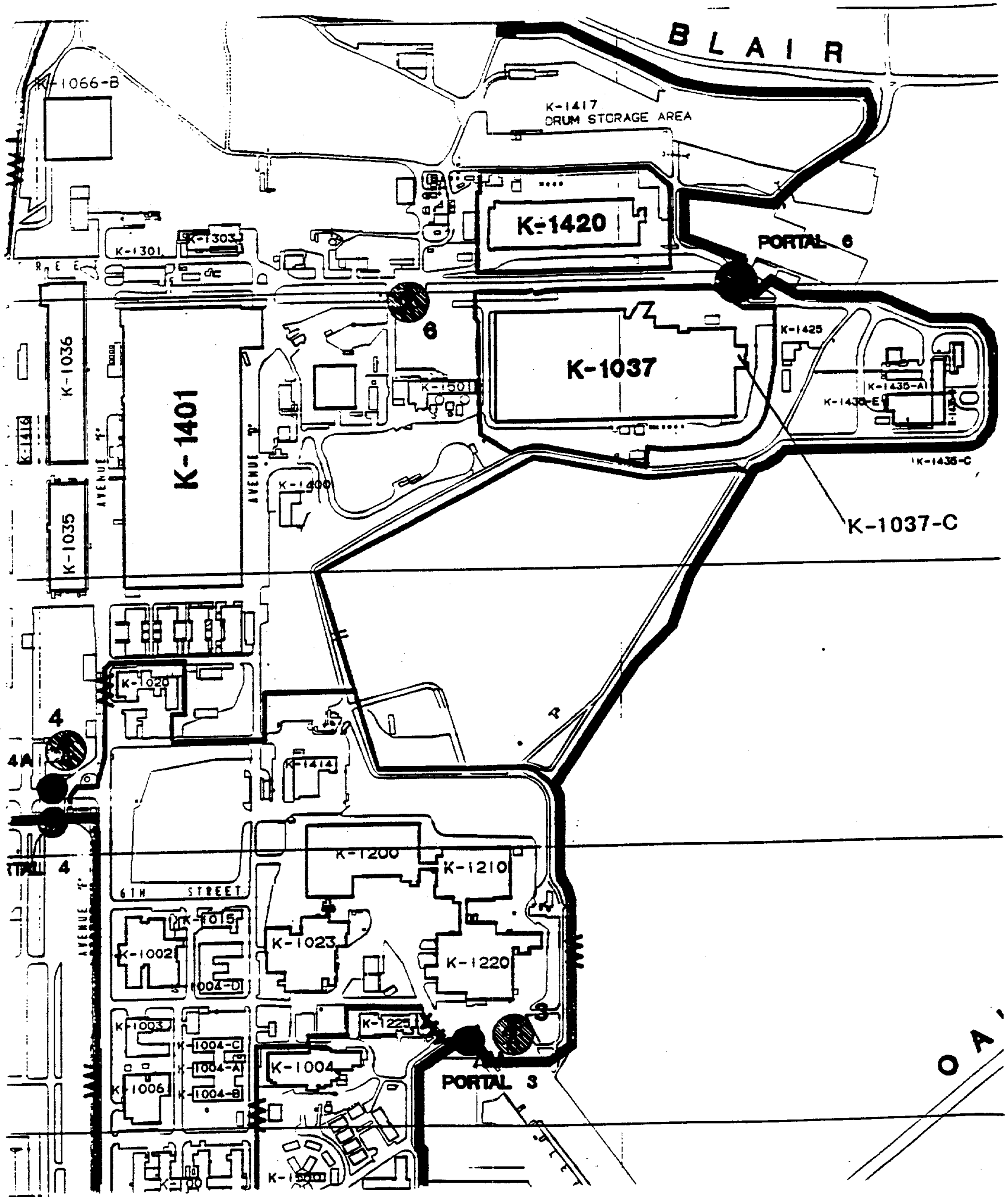



Fig. 3.1. Building K-1037 location.

## 3.3 PRINCIPAL PROCESSES

Building K-1037 was the sole manufacturer of process barrier in the country. Equipment was provided to produce barrier in multiple parallel production lines for installation in the three gaseous diffusion enrichment plants. The process description is not discussed in this document because of security classification, but can be found in K/GH-500, Part 1, *CIP/CUP Technology*.[9]

The production equipment was shut down and placed in standby upon completion of the Process Equipment Modification Program in 1981. Most of the barrier production equipment remains as it was during operation. The ventilation ducting has been isolated and sealed and partitioning has been provided to confine the toxic nickel powder to the standby production area, which is monitored by Site Facility Operations. Those areas occupied by AVLIS, Waste Management, and other personnel are isolated from the hazards discussed in this HS Analysis.

### 3.3.1 Scrap Smelter

K-1037-C is constructed of corrugated transite on steel frame with a concrete floor. The building is approximately 5000 $ft^2$ and is an addition to the east end of K-1037. The building housed a smelter which was provided to smelt "off-spec" scrap nickel barrier and produce ingots for recycle. The smelter area has been designated as a radiological/contamination area with restricted personnel access. It is also a security area.

The smelter "off gas" was discharged through large scrubber type vessels located on the east end of the second floor of the barrier production area. These vessels have internal radioactive contamination levels of greater than 100,000 dpm/100 $cm^2$.

A nondestructive assay (NDA) survey of these vessels indicates an inventory of approximately 2 g uranium of natural or depleted $^{235}U$ content with 0.1 mg of neptunium present.[10] This equipment contamination is posted and controlled by the K-25 Site Health Physics program to restrict personnel access. The hazard is judged to be adequately controlled and no further hazard analysis is required.

### 3.3.2 Barrier Production Area

The main barrier production area of K-1037 comprises approximately 60 percent of the building or 185,000 $ft^2$. Barrier production involved the continuous handling of tonnage quantities of nickel powder. This fine powder was widely dispersed throughout the production area. Sections of the building, which could be cleaned of the powder and isolated by sealed partitions and isolation of the central heating, ventilating and air conditioning system, are not occupied by personnel from the Energy Systems divisions as described earlier. Hazardous material was cleaned from process equipment after production was discontinued. As described in K/P-6751, *Procedures for the Shutdown, Standby, and Restart of Barrier Manufacturing Facility I, K-1037*,[11] the process chemical storage tanks were also cleaned of their inventory and steam purged. Personnel access to this area is restricted because of security concerns.

### 3.3.3 Basement

The K-1037 first floor production area is provided with a basement service area which is approximately 100,000 ft$^2$. The elevation of this floor is 768 ft above sea level. Services provided in the basement include electrical substations and transformers and the steam supply and pressure reducing station and steam condensate system.

Many of the barrier production facility process control consoles are located in this area under the processing equipment on the first floor. The basement area under the section occupied by AVLIS is sealed from the remaining basement area to prevent dispersion of the nickel powder hazards present in the basement.

## 3.4 HAZARD SOURCE INFORMATION

The hazards associated with the Site Facility Operations portion of Building K-1037 are identified in the PHS Work Sheets (Appendix A). This document was generated by the FSET based on an extensive walkdown of the facility, discussions with facility personnel, and a discussion with the facility manager regarding status of the shutdown systems.

# 4. HAZARD SCREENING

This section includes HS Work Sheets for this facility.

These four work sheets (Fig. 4.1 through Fig. 4.4) present the results of the HS process:

- Preliminary Hazard Identification Matrix
- Preliminary Hazard Analysis Work Sheet
- Hazard and Operability Study (HAZOP) Work Sheet
- Hazard Classification Input Form

## 4.1 HAZARD IDENTIFICATION

### 4.1.1 Preliminary Hazard Identification Matrix

In the first of these work sheets, the Preliminary Hazard Identification Matrix (Fig. 4.1), each system discussed in the facility description is identified. If any of the ten hazards listed in the matrix exists for a particular system, the specific hazard is listed and specific information about the hazard is provided in the remarks column.

Three of the ten hazard categories listed in the Preliminary Hazard Identification Matrix are identified as being present in the K-1037 building. These hazards include Radiation Sources, Toxic/Corrosive/Reactive Material, and Electrical Energy. Those hazards categorized as Special Nuclear Material, Flammable Materials, Explosive/Pyrophoric Materials, Thermal Energy, Kinetic Energy, and Potential Energy are not present in this facility.

#### 4.1.1.1 Special Nuclear Material

An inadvertent criticality is considered to be the most significant potential source for radiation exposures in any of the K-25 Site facilities. The probability of such an event is low, but the consequences could be severe.

$^{235}U$ enrichments greater than 1 percent constitute fissile materials. Since the radioactive contamination in the barrier smelter area has been determined by NDA survey to be less than 1 percent $^{235}U$, the Special Nuclear Material hazard does not exist in this facility.

DATE: March 1992

FACILITY: K-1037 Building

Hazard Type

| Item No. | System/Subsystem Description | Special Nuclear Material | Radiation Sources | Toxic/ Corrosive/ Reactive Material | Flammable Materials | Explosive Pyrophoric Materials | Electrical Energy | Thermal Energy | Kinetic Energy | Potential Energy | Other | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | Scrap Smelter (K-1037-C) | | 1 | 2 | | | | | | | | 1-2. Residual radioactive and toxic uranium materials less than or equal to 100,000 dpm/100 $cm^2$ |
| 2.0 | Barrier Production Areas | | 1 | 2 | | | | | | | | 1. Vessels on second floor have internal contamination.<br>2. Nickel powder is dispersed throughout area on building and equipment surfaces. |
| 3.0 | Basement | | | 1 | | | 2 | | | | | 1. Nickel powder is dispersed throughout area on building and equipment surfaces.<br>2. 13.8 kV supply to substation and transformers |

Fig. 4.1. Preliminary hazard identification matrix.

#### 4.1.1.2 Radiation Sources

Uranium is an alpha radiation emitter. Uranium alpha radiation cannot penetrate the dead outer layer of the skin. Thus, uranium itself cannot cause any radiation exposure as long as it is outside the body and poses an exposure potential only if it enters the body by some means. The possible inhalation of uranium dust is the most significant source for such intake. The ingestion of uranium-that is, intake by swallowing uranium materials-is far less significant, largely because it is readily controlled by normal good personal hygiene practices, such as washing hands before heating or smoking.

$^{238}U$ decays to daughter products that emit beta and minute amounts of gamma radiation and which themselves decay to $^{234}U$. The beta and gamma radiations can penetrate the skin and can produce radiation exposure, primarily to the body tissues immediately beneath the skin. The levels of radiation exposure from the daughter products associated with uranium surface contamination is generally very low.

During the plant's operating history, many tons of uranium recovered from spent reactor fuels were fed to the cascade. Most of the fission products and transuranic elements (neptunium and plutonium) were removed from the uranium in chemical recovery operations and conversion of the uranium to $UF_6$ before delivery to the K-25 Site. Traces of these elements did carry through the processes, however, and were introduced into the diffusion cascade. Traces of plutonium and neptunium were introduced into the cascade where they contaminated the barrier. Some of the contaminated barrier was later smelted. Neptunium and plutonium are both alpha radiation emitters, and the same protective measures used to prevent exposure of personnel to uranium will also prevent exposure to those isotopes. It is anticipated that they will have no effect on the final risk assessments; however, their presence is noted.

#### 4.1.1.3 Toxic Materials

Health effects from the chemical toxicity of soluble uranium and technetium compounds, such as the fluoride or oxyfluoride residues found in this facility, are greater than radiotoxicity effects. Renal injury may result from acute exposure to inhaled or ingested soluble material. The insoluble uranium compounds are not present in significant quantities in this facility.

Toxic nickel powder is dispersed through the barrier production areas and basement. Other toxic process chemicals used in the barrier production activity were cleaned from the equipment and the process systems were purged with steam to ensure an acceptable hazard level (refer to Reference 11).

### 4.1.2 Preliminary Hazard Analysis Work Sheet

In the second work sheet, the Preliminary Hazard Analysis Work Sheet (Fig. 4.2), each system of the facility is listed, and the hazard types identified in the Hazard Identification Matrix are listed. The Consequence and Initiating Event columns are left blank in this work sheet and completed on the HAZOP Work Sheet. The sixth column is used to label the hazard as a standard industrial hazard or a nonstandard industrial hazard, and the justification for this judgment is presented in the seventh column.

DATE: March 1992

FACILITY: K-1037 Building

| Item No. | System/Subsystem Description | Hazard Type | Consequence | Initiating Event | Standard Industrial Hazard | | Justification for Standard Industrial Hazard and Comments |
|---|---|---|---|---|---|---|---|
| | | | | | Yes | No | |
| 1.0 | Scrap Smelter | Radiation Sources | | | | N | |
| | | Toxic Material | | | | N | |
| 2.0 | Barrier Production Areas | Toxic Material | | | | N | Nickel powder dispersion analysis, exposure levels, and hazard class from Central Safety Evaluation Team (CSET)-2, Appendix B, C, and D |
| | | Radiation Sources | | | | N | Smelter vent scrubber in K-1037 second floor has internal contamination |
| 3.0 | Basement | Toxic Material | | | | N | Nickel powder dispersion analysis, exposure levels, and hazard class from CSET-2, Appendix B, C, and D |

Fig. 4.2. Preliminary hazard analysis work sheet.

The barrier production facility "nonwork" surface contamination area is less than 790,000 $ft^2$ at 10,000 dpm/100 $cm^2$ with contaminated areas controlled as required by DOE Order 5480.11.[12] Therefore, as shown in Appendices B and C, the toxic, radiological, and criticality effects are evaluated as a "Generally Accepted" hazard and further evaluation of this removable contamination is not warranted, except for K-1037-C, Smelter, which had higher contamination levels.

Appendix C analyzes a case for removable surface contamination which bounds K-1037-C. Appendix C shows that for a building whose surface area is 100 percent contaminated with transferrable contamination at 10,000 dpm/100 $cm^2$, the health effects to an individual located outside within 100 m can be considered negligible if the longest side of the building is less than 313 m, reversible if it is between 313 m and 601 m, and irreversible if it is greater than 601 m. The health effects to an individual inside the facility would also be negligible if the individual exited the building in less than 313 s, reversible if the egress time is between 313 s and 601 s, and irreversible if the time is greater than 601 s. Generally, it is assumed that a person's walking speed is 1.0 m/s or 1.5 m/s.

This case approximates K-1037-C. Contamination exists on less than 100 percent of the surface area, 100,000 dpm/100 $cm^2$ is the maximum contamination level found in the facility, and K-1037-C's longest side is only about 40 m. Also the actual ceiling heights (approximately 20 ft) are higher than the 10 ft height in the bounding case, which would reduce concentrations.

The facility auxiliary transformer is supplied from a 13.8 kV feeder. As defined in CSET-2, the 13.8 kV electrical distribution system hazards are "Generally Accepted" or are Standard Industrial Hazards because they are adequately addressed by Occupational Safety and Health Administration regulations and one or more National Consensus Standards (e.g., NFPA 70, IEEE, etc.) that define special safety requirements. These regulations and standards are implemented by K-25 Site procedures. Access to live parts is physically or administratively restricted to qualified and trained personnel.

The remaining hazard category, Toxic/Corrosive/Reactive Materials, was subjected to further analysis by completing a HAZOP work sheet and identifying a worst-case scenario leading to severe consequences.

## 4.2 INITIATING EVENT IDENTIFICATION AND SELECTION

### 4.2.1 HAZOP Work Sheet

The HAZOP Work Sheet (Fig. 4.3) presented in this selection summarize the results of the modified HAZOP review of Building K-1037.

DATE: March 1992

FACILITY: K-1037 Building

SYSTEM/SUBSYSTEM: Barrier Production Areas

DESIGN INTENTION: Barrier Production and Inspection. Permanently shutdown.

HAZARDS IDENTIFIED IN PHA: Toxic Nickel Powder

| DEVIATION | CONSEQUENCES | INITIATING EVENT | PROTECTION |
|---|---|---|---|
| Dispersion of toxic nickel powder to the building | Inhalation of toxic nickel powder | Seismic event or major maintenance activities | |

Fig. 4.3. HAZOP work sheet.

DATE: March 1992

FACILITY: K-1037 Building

SYSTEM/SUBSYSTEM: Basement Area

DESIGN INTENTION: Process Control Area and Service Area for Barrier Production Facility

HAZARDS IDENTIFIED IN PHA: Toxic nickel powder

| DEVIATION | CONSEQUENCES | INITIATING EVENT | PROTECTION |
|---|---|---|---|
| Dispersion of nickel powder to the building | Inhalation of toxic nickel powder | Seismic event or major maintenance activities | |

Fig. 4.3. HAZOP work sheet (continued).

Each hazard entry in the Preliminary Hazard Analysis Work Sheet is addressed in the HAZOP Work Sheets, which contain four columns: Deviation, Consequences, Initiating Event, and Protection. The Deviation column lists the deviations from normal conditions which lead to consequences associated with a particular hazard. The Consequences column identifies the worst-case scenario resulting from a particular deviation. The Initiating Event column lists some of the potential events that can result in the deviation of interest. The Protection column presents both active and passive equipment features and operating procedures designed to reduce the likelihood of one or more initiating events producing the given consequences or reducing the severity of the given consequences.

### 4.2.2 National Phenomena Evaluation Team Input

#### 4.2.2.1 Seismic

Although a seismic analysis was not performed for this facility, it is similar to other K-25 Site buildings which meet the "General Use" criteria (the lowest level of seismic resistance).[13]

#### 4.2.2.2 Flood

The ground floor of K-1037 is 8 ft above the probable maximum flood (PMF) evaluation of 780 ft above sea level. The elevation of the basement floor is 12 ft below the PMF elevation.[14] Flooding is not considered a credible initiating event for a potential hazard in this facility.

## 4.3 SCENARIO DEVELOPMENT

### 4.3.1 Hazard Classification Input Form

A Hazard Classification Input Form (Fig. 4.4) was completed for each hazard type addressed by the HAZOP Work Sheet and represents the accident scenario that involves the most significant consequence for that hazard type.

Further evaluation of the following hazard and scenarios is recommended to determine if additional safety documentation is required:

- Toxic Materials - Dispersion of toxic nickel powder to the atmosphere.

## 4.4 CONSEQUENCE DETERMINATION

Based on the scenarios presented on the hazard classification input forms, consequences were estimated for the release of nickel powder.

DATE: March 1992

FACILITY: K-1037 Building

SCENARIO DESCRIPTION: Dispersion of toxic nickel powder to the atmosphere from basement area of K-1037 due to seismic event or major maintenance activity

Hazard Material Releases

1. What material/materials are released? **(nickel powder)**
2. What are the chemical/physical characteristics of the material? **(toxic, carcinogen)**
3. What is the release mechanism (e.g., fire,explosion, spill)? **(nickel powder contamination becomes airborne)**
4. For pressurized releases, what is the temperature and pressure of the release? Temp = Pressure =
5. How much of the material is available to be released? How much of the material becomes airborne (i.e., release fraction)? **(300 lb)**
6. Where is the material released from/to? (Provide release height if known.) **(into building)**
7. If material is released into an enclosed area, what is the volume of the enclosure? **($9.29 \times 10^4$ $m^3$)**
8. If material is released into a ventilated area, what is the ventilation rate? **(ventilation system shut down, isolated)**

Criticality Accidents

1. What are the chemical/physical characteristics of the material?
2. How much mass of fissionable material is present?
3. What is the enrichment of the material?
4. What is the expected configuration of the material?
5. What is the nature of the surroundings (i.e., presence of moderator or reflector)?

All Accident Scenarios

1. How many people are located in the immediate vicinity of the accident? **(less than 6)**
2. How far is the nearest exit from the vicinity of the accident (i.e., how far would an individual need to go to evacuate the area)? **(less than or equal to 250 m)**
3. How does operator "sense" release? What physical occurrence is going to signal operator or operators to evacuate? How long before operator evacuates? **(Seismic event will result in timely [immediate] evacuation. Dust cloud from maintenance activity will alert personnel to leave area promptly [unless evaluated, with protective measures taken]).**

**Fig. 4.4. Hazard classification input form.**

DATE: March 1992

FACILITY: K-1037 Building

SCENARIO DESCRIPTION: Dispersion of toxic nickel powder to the atmosphere from Barrier Production Areas due to seismic event or major maintenance activity

Hazard Material Releases

1. What material/materials are released? **(nickel powder)**
2. What are the chemical/physical characteristics of the material? **(toxic, carcinogen)**
3. What is the release mechanism (e.g., fire,explosion, spill)? **(nickel powder contamination becomes airborne)**
4. For pressurized releases, what is the temperature and pressure of the release? Temp = Pressure =
5. How much of the material is available to be released? How much of the material becomes airborne (i.e., release fraction)? **(300 lb)**
6. Where is the material released from/to? (Provide release height if known) **(into building)**
7. If material is released into an enclosed area, what is the volume of the enclosure? **($9.29 \times 10^4$ $m^3$)**
8. If material is released into a ventilated area, what is the ventilation rate? **(ventilation shut down, isolated)**

Criticality Accidents

1. What are the chemical/physical characteristics of the material?
2. How much mass of fissionable material is present?
3. What is the enrichment of the material?
4. What is the expected configuration of the material?
5. What is the nature of the surroundings (i.e., presence of moderator or reflector)?

All Accident Scenarios

1. How many people are located in the immediate vicinity of the accident? **(less than 6)**
2. How far is the nearest exit from the vicinity of the accident (i.e., how far would an individual need to go to evacuate the area? **(less than or equal to 250)**
3. How does operator "sense" release? What physical occurrence is going to signal operator or operators to evacuate? How long before operator evacuates? **(Seismic event will result in timely [immediate] evacuation. Dust cloud from maintenance activity will alert personnel to leave area promptly [unless previously evaluated, with protective measures taken]).**

**Fig. 4.4. Hazard classification input form (continued).**

### 4.4.1 Release of Nickel Powder

For the close-in estimate (i.e., individuals located inside the facility and individuals located outside the facility within 100 m), the greatest time-weighted average concentration (1.22 mg/m$^3$) and cancer risk (5.74 $\times$ 10$^{-3}$) were found for an exposure time of 250 s (Appendix D). This is the maximum amount of time that the individual outside the facility would be exposed, and much longer than the individual inside the facility is likely to be exposed. The time-weighted average concentration is well below one-tenth the immediately dangerous to life and health (IDLH) value (50 times threshold limit value [TLV] of 1.0 mg/m$^3$) and the cancer risk is well below 0.008. Therefore, in accordance with CSET-2, the on-site health effects are found to be negligible.

For the off-site individual, the greatest effects occurred at 100 m from the facility. The time-weighted average concentration of 14 mg s/m$^3$ is well below one-tenth the IDLH value (50 times TLV of 1.0 mg/m$^3$) and the cancer risk of 2.2 x 10$^{-6}$ is well below 0.008. The seeming discrepancy between the time-weighted average concentrations and cancer risks determined for the individuals located at 100 m for the close-in estimate and the off-site estimate is due to air dispersion being considered for off-site and not considered for close-in. In accordance with CSET-2, the health effects for off-site exposure are considered negligible.

## 4.5 INITIAL HAZARD CLASSIFICATION

Based on the consequences associated with the release of nickel powder to the atmosphere, the recommended hazard classification for Building K-1037, including K-1037-C, is "Generally Accepted$^{\alpha\beta\gamma}$," as shown in Table 4.1.

**Table 4.1. Hazard classification summary**

| Accident scenario | Hazard | Facility hazard classification | Credible scenario |
|---|---|---|---|
| Dispersion of nickel powder to the atmosphere | Toxic material | Negligible | Yes |

# 5. SAFETY DOCUMENTATION REQUIREMENTS

## 5.1 ADDITIONAL SAFETY DOCUMENTATION REQUIRED

No further safety analysis is required for the Barrier Plant area of Building K-1037 assigned to Site Facility Operations. It is assumed that the remaining areas are described in documents prepared for AVLIS.

## 5.2 ANALYSIS ASSUMPTIONS AND OPERATING LIMITS

This Phase I HS assumes that the part of K-1037 Barrier Plant assigned to Site Facility Operations will be maintained in its existing shutdown status. It is assumed that the current level of surveillance, monitoring, and facility maintenance activity will continue to be directed by the Site Facility Operations organization management until Decontamination and Decommissioning Division of the K-25 Site is initiated.

Specific safety analysis documentation will be developed and approved for activities which deviate from those detailed in this document.

# 6. MATERIALS AND HAZARDS THAT COULD AFFECT OTHER FACILITIES

There are no material or hazards in the portion of the building assigned to Site Facility Operations that could affect other facilities adjacent to the K-1037 building.

# 7. REFERENCES

1. DOE/OR-901, *Guidance for Preparation of Safety Analysis Report*, U.S. Department of Energy—Oak Ridge Operations, Rev. 1, December 1990.

2. K/D-5604, *Final Safety Analysis Report Oak Ridge Gaseous Diffusion Plant*, Martin Marietta Energy Systems, Inc., Oak Ridge K-25 Site, March 1985.

3. Central Safety Evaluation Team, CSET-1, Rev. 1, *Safety Analysis Report Update Program, Overview and Phase I Implementation*, Martin Marietta Energy Systems, Inc., March 1991.

4. Central Safety Evaluation Team, CSET-2, *Safety Analysis Report Update Program, Hazard Screening Application Guide*, Martin Marietta Energy Systems, Inc., December 1990.

5. Central Safety Evaluation Team, CSET-3, *Safety Analysis Report Update Program, Logic Model Application Guide*, Martin Marietta Energy Systems, Inc., January 1991.

6. Central Safety Evaluation Team, CSET-4, *Safety Analysis Report Update Program, Risk Reduction Action Plant Application Guide*, Martin Marietta Energy Systems, Inc., April 1991.

7. Central Safety Evaluation Team, CSET-5, *Safety Analysis Report Update Program, Natural Phenomena Applications Guide*, Martin Marietta Energy Systems, Inc., March 1991.

8. R. N. Thurmer, *Oak Ridge K-25 Site Decontamination and Decommissioning Project*, FY 1991, *Funding Review*, K/K DD-1, Revision 1, Martin Marietta Energy Systems, Inc., Oak Ridge K-25 Site, November 1990.

9. Goodyear Atomic Corporation, *CIP/CUP Technology; Barrier*, K/GD-500, Part 1, Addendum 1, Union Carbide Corporation Nuclear Division, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, March 1977. SECRET-RD.

10. R. L. Mayer, ESP92-105, letter, *NDA Analysis of K-1037*, to R. A. Kite, Enrichment Safeguards Program, Martin Marietta Energy Systems, Inc., Oak Ridge K-25 Site, March 10, 1992.

11. C. R. Levenhagen, *Procedures for the Shutdown, Standby, and Restart of Barrier Manufacturing Facility I, K-1037*, K/P-6751, Union Carbide Corporation Nuclear Division, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, February 4, 1983. CONFIDENTIAL-RD.

12. DOE Order 5480.11, *Radiation Protection for Occupational Workers*, U.S. Department of Energy, Washington, D.C., June 29, 1990.

## REFERENCES (continued)

13. DOE Order 6430.1A, *General Design Criteria Manual*, U.S. Department of Energy, Washington, D.C., April 6, 1989.

14. R. P. Kennedy et al., *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, UCRL 15910, June 1990.

# APPENDIX A

# PRELIMINARY HAZARD SCREENING
# FOR
# BUILDING K-1037 BARRIER PLANT

MARTIN MARIE

Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS. IN

October 28, 1991

R. L. Faulkner, Division Manager - Decontamination and Decommissioning
J. R. Jamison, Division Manager - AVLIS

Approved Preliminary Hazard Screening (PHS) Document for K-1037

The K-25 Safety Analysis Review Group has reviewed and approved the PHS for your facility. Copies are attached for information and use by your office and your facility manager. The original will be maintained by the K-25 Site Installation Facility Safety Manager (IFSM).

The PHS identified one or more hazards requiring additional analysis, the next step in the Safety Analysis Report Update Program (SARUP). Therefore, a copy will also be provided to the Hazard Analysis Project Engineer for use in assisting your Facility Safety Evaluation Team (FSET) and/or Facility Manager in completing the Hazard Analysis.

Any proposed changes to the facility, operations or systems must now be evaluated and documented using the PHS criteria. Any original documented reevaluation must be sent to the IFSM for review and approval.

The PHS is your "interim license" pending completion of the Hazard Analysis. Conformance of your facility to the criteria is subject to review by the Facility Safety Department. DOE Order 5480.5 requires an annual appraisal of each facility to assess aspects of facility operation including conformance to safety documentation (DOE 5480.5-9.g,h). Guidance on such appraisals will be issued by the Health, Safety and Environmental Management (HS&EM) Division.

Should you have any questions about the PHS or remaining steps in the program, contact the IFSM, Cliff Watson at 6-7860.

Clifford Watson

C. C. Watson, K-1020, MS-7403, K-25 (6-7860)

CCW:mr

Attachment

cc w/att: John Bolling (Emergency Preparedness Department Manager)
K-25 System Safety Engineering - RC
File - IFSM (2)

Preliminary Hazard Screening No.: PHS/K-1037/PK/354.1 10-22-91

# PRELIMINARY HAZARD SCREENING WORK SHEET

Facility Location: K-1037 Room(s): ALL

Facility Manager: NA Division: NA Year Built: NA.

Facility/Description: (circle or shade on map) SEE ATTACHMENTS.

Because of the historical classification of activities in K-1037, the classification of AVLIS activities, and that K-1037 usuage crosses divisional lines, the K-1037 PHS has been organized as shown in Figure 1. Each PHS and Safety Assessment on Figure 1 is enclosed. Earlier AVLIS PHS Worksheets are superseded based on September 25, 1991 discussion in K-1037. Attending were Judy Joyner, Fran Lusby, J.R. Jamison, C.B. Bryan, and R.K. Wagenbe-

Waste Storage Locations:

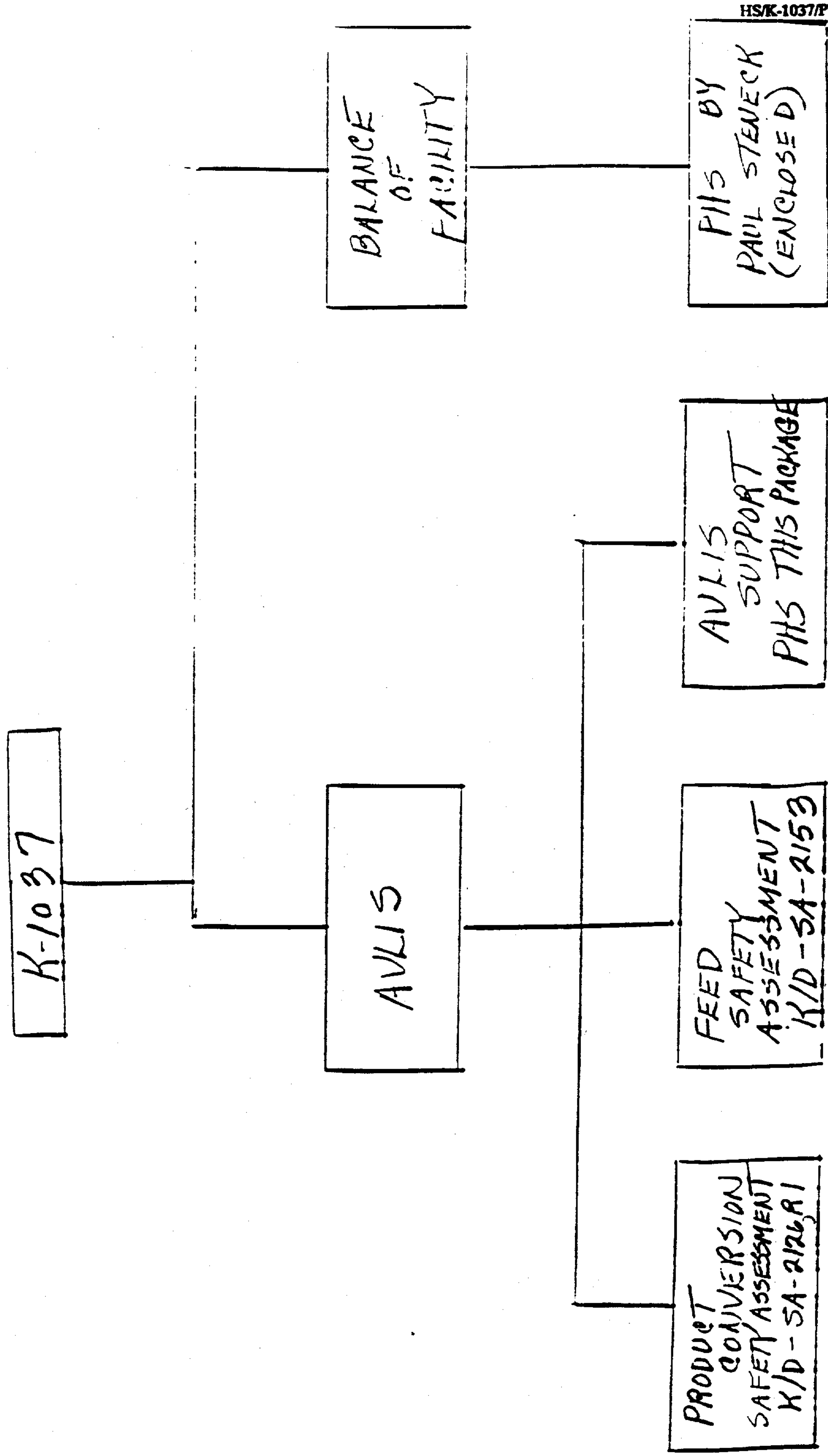
Description of Stored Material:

Division Manager/Rep. Date

KSARG Review 10/22/91 Date

N/A PSEF Approval Date

ORGANIZATION OF K-1037 PHS



Preliminary Hazard Screening No.: ____

# PRELIMINARY HAZARD SCREENING WORKSHEET

Facility Location: East side of the K-25 Site in Sector 1, South of K-1420, West orthe K-1435 facilities

Room(s): K-1037 (excludes AVLIS)

Facility Manager: RK Johnson
R. L. Faulkner (4-9188)

Division: D & D

Year Built: 1954

Facility/Description: (circle or shade on map)

**See Attachment 1**

Waste Storage Locations:

**See Attachment 1**

**Description of Stored Material:**

**See Attachment 1**

R.L. Faulkner for RK Johnson 8/16/91
Division Manager/Rep. Date

PSET Approval 10/22/91 Date

Bill Allington William / Allington 8/13/91
System Safety Engineer Date

for R.L. Jones 10/22/91
~~ES~~ARG Review Date

Paul Steneck Paul A. Steneck 8/13/91
Facility Safety Engineer Date

Al Hoose Al Hoose 8/13/91
System Safety Engineer Date

# ATTACHMENT 1

**SCOPE:** The K-1037 building is a multi-use facility that currently houses offices, process areas, mock-up areas, and storage of equipment and materials from previous K-1037 programs. The AVLIS program is currently using approximately 40% of the building, predominantly in the north to northeast section of the facility. A preliminary hazard assessment for the AVLIS program has been completed and is available separate from this document, and as such, is outside the scope of this assessment.

**FACILITY/DESCRIPTION:** A description of the K-1037 building from an approved K-25 safety document is attached. Also see the plan view drawing of the facility, SIE 54512, AVAIS Lab. Modifications, AIS-Barrier Separation Plans and Sections, also attached.

**FACILITY LOCATION:** The K-1037 Industrial Research Building is located in Sector 1, just south of the K-1420 Decontamination Facility, and west of the K-1435 facilities.

***Waste Storage Location:*** There are no waste storage areas associated with the K-1037 facilities described by this document. However there is a significant amount of stored equipment and other materials associated with this facility.

***Description of Stored Material:*** There is a significant amount of stored equipment and materials located throughout K-1037. The majority of the equipment has been left in place. All power connections appeared disconnected. All tanks appeared empty. Some equipment has been relocated and stored in some parts of the building in a fairly tight packed arrangement. Some open pails of metal powder were observed during the walk-through. An unlabeled 55 gallon drum of liquid was also observed among some stored equipment. The majority of all of the process related equipment can be considered as either idle and/or abandoned in place.

ESET / DR

# Preliminary Hazard Screening Worksheet

| HAZARD | MEASURE | ACTION* | ACTION DECISION | ACTION DECISION BASIS |
|---|---|---|---|---|
| RAD WASTE | >0.002 µCi/g | KEEP | SCREEN-OUT (S.O.) | NONE PRESENT |
| RADIOACTIVE MATERIALS | > LEVELS IN 5480.11 | KEEP | S.O. | NONE PRESENT |
| X RAY | DOESN'T MEET ANSI X-RAY STANDARDS | KEEP | S.O. | NONE PRESENT |
| TOXIC MATERIALS | MASS/1000 ft³ > IDLH/2 | KEEP | KEEP | OPEN POWDER BARRELLS |
| REACTIVE MATERIALS | HAZARD LEVEL ≥ 2 PER EPM-110 | KEEP | S.O. | NONE PRESENT |
| FLAMMABLE MATERIAL | >110 gal (TWO 55 gal DRUMS) | KEEP | S.O. | NATURAL GAS LINES ARE ROUTED TO A GAS CRACKER SYSTEM. SYSTEM IS SHUT DOWN. ALL GAUGES READ "0." NO PLANS TO REACTIVATE. |
| EXPLOSIVES | ANY HIGH/CLASS A OR B | KEEP | S.O. | NONE PRESENT |
| | >10 oz. OF LOW HI ONE AREA/CLASS C | KEEP | S.O. | NONE PRESENT |
| CHEMICAL INCOMPATIBILITY | ≥2 INCOMPATIBLE CHEMICALS IN SAME AREA | KEEP | S.O. | NONE PRESENT |
| LASERS | CLASS I OR II | SCREEN OUT | S.O. | NONE PRESENT |
| | CLASS III W/BEAM ENCLOSED | SCREEN OUT | S.O. | NONE PRESENT |
| | CLASS III NONENCLOSED BEAM & CLASS IV | KEEP | S.O. | NONE PRESENT |
| ELECTRICAL VOLTAGE/CURRENT | 600V AND > 25mA OUTPUT, 50 J STORED ENERGY AT 50V | KEEP | KEEP | THERE IS AN EXTENSIVE AMOUNT OF ELECTRICAL DISTRIBUTION AND SWITCHGEAR IN THE BASEMENT OF BLDG. K-1037. SEVERAL 13.8KV TRANSFORMERS ARE PRESENT. |
| KINETIC ENERGY | "UNIQUE," i.e. HIGH ENERGY FLY WHEEL | KEEP | S.O. | NONE PRESENT |
| PRESSURE | >3000 PSIG | KEEP | S.O. | NONE PRESENT |
| | >0.1 lb TNT EQUIV. ENERGY | KEEP | S.O. | NONE PRESENT |
| TEMPERATURE | RESULTS IN UNACCEPTABLE SITUATION OR BYPRODUCT | KEEP | S.O. | NONE PRESENT, SYSTEMS DEACTIVATED - NO PLANS TO RESTART |
| BIOHAZARD | SPECIAL CONTROLS REQUIRED | KEEP | S.O. | NONE PRESENT |
| ASPHYXIANTS | EFFECT LARGE NO. OF PEOPLE | KEEP | S.O. | NONE PRESENT |
| OTHER OR UNKNOWN | | | — | NONE OBSERVED OR NOTED |

Facility Number: K-1057
EXCLUDES AVLIS

Facility Name: INDUSTRIAL RESEARCH

# POTENTIAL HAZARD PUNCH LIST

## Preliminary Hazard Screening Work Sheet

R. L. FAULKNER
Facility Manager
R. L. Faulkner by [illegible] 8/16/91
Signature Date

PAUL D. STENECK
Facility Safety Engineer
[signature] 8/13/91
Signature Date

AL HOOSE
System Safety Engineer
[signature] 8/13/91
Signature Date

| # | DESCRIPTION OF UNKNOWNS & HAZARDOUS MATERIALS (55 gal drum, 500 gal tank, etc.) | QUANTITY | LOCATION | STATUS (generator/stored/interim, etc.) | POTENTIAL DISPOSITION DATE (analysis) | REMARKS |
|---|---|---|---|---|---|---|
| 1 | 30 GAL DRUM - LIQUID | 1 | @ COLUMN U-27 EAST | | | |
| 2 | 55 GAL DRUM - LIQUID | 1 | @ [illegible] MACHINES - COLUMN S-31 | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |

# APPENDIX B

## K-25 SITE SURFACE CONTAMINATION POSITION PAPER

# K-25 SITE SURFACE CONTAMINATION POSITION PAPER

## Statement of Problem

Surface contamination above the screening levels in CSET-2 (Reference 1) is a common hazard at the K-25 Site. These are not considered a Standard Industrial Hazard and must go through a formal Hazard Screening Analysis. However, contaminated surfaces are identified, characterized, and controlled by the K-25 Site procedures and maintained at ALARA levels, as required by DOE Order 5480.11, such that the consequences from potential exposures from "nonwork" surfaces are expected to pose no appreciable health consequences. "Nonwork" surfaces are defined as:

> *Floors, walls, ceilings, walkways, external surfaces of process enclosures (cell housings, hot cells, glove boxes, etc.), handrails, windows, electrical utilities, HVAC components, and plumbing fixtures. Also, for the purpose of this evaluation, nonwork surfaces include furniture surfaces such as chairs, desks, tables, stools, countertops, lockers, benches, cabinets, vending machines, and appliances. (Reference 3)*

A conservative evaluation of contaminated "nonwork" surfaces for Hazard Screening is provided. This evaluation is intended to eliminate those facilities that clearly pose a negligible hazard to persons on-site and off-site due to uranium contamination, when in compliance with DOE Order 5480.11. Facilities determined to require further analysis may well be determined to pose no significant hazard once a specific analysis is completed.

## Background

As a result of processes involving radioactive materials, surface contamination is present in many areas of the K-25 Site. Radiation protection for workers is regulated by DOE Order 5480.11 (Reference 2) and ORO Radioactive Contamination Control Policy (Reference 3). Energy Systems Standard Practice Procedures 804 and 808 (References 4 and 5) and the K-25 Site Interim Health Physics Guide INT-0010 (Reference 6) define survey, control and reporting criteria which implement the requirements of the DOE Order and ORO Policy. Energy Systems Standard Practice Procedure 609 (Reference 7) implements an ALARA program which ensures that contamination levels are minimized with respect to the potential exposure of occupational workers.

Contamination may be fixed or removable. Fixed contamination is impregnated within the material and cannot be removed by ordinary means, such as wiping or washing. Thus, it is not considered a significant hazard to the public or general employee. Exposure of occupational workers to fixed contamination is limited to levels established by DOE Order 5480.11. (Reference 8).

Removable contamination represents a more significant exposure to occupational workers since it may become airborne by mechanical impact or air currents. In order to maintain exposure ALARA, every effort is made to minimize removable contamination. However, because of the potential for airborne release due to a catastrophic event (e.g., fire, tornado, explosion, etc.) or criticality, removable "nonwork" surface contamination shall be evaluated for a worst case scenario.

Evaluation

There are three concerns associated with surface contamination as described herein. The atmospheric release of radiation which might affect persons off-site is the first concern to be addressed. Second, the potential for a nuclear criticality as a result of the collection of removable surface contamination washed from surfaces is considered. Finally, the potential effects of an atmospheric release to persons on-site are evaluated. In actuality, the chemical toxicity of uranium is such that chemical toxicity is the controlling factor in setting the exposure limits to airborne uranium. Thus, the evaluations for the effects of airborne uranium presented herein will consider limits resulting from the chemical toxicity as the bounding condition.

While health effects due to radiation are generally characterized as a function of the dose received per mass unit, expressed in rems, the typical measure of contamination available from health physics surveys is given in disintegrations per minute (dpm) per 100 cm$^2$ of surface area. Thus, the calculations herein are presented in terms of the contamination measures.

Off-Site Radiological/Chemical

The United States Nuclear Regulatory Commission (NRC) requires, per 10 CFR 70.22, an emergency plan or an evaluation showing that the maximum dose to a person off-site due to a release of radioactive material would not exceed 1 rem effective dose equivalent or an intake of 2 mg of soluble uranium. Uranium and plutonium are addressed in 10 CFR 40.31 and 10 CFR 70.22. The limit for plutonium is 2 curies. The limit for uranium, because of its acute chemical toxicity, is 1000 kilograms of uranium hexafluoride. This corresponds to a level of radioactivity from 0.3 curies to 50 curies, depending on enrichment (i.e., from 0.2% to 97.5%). Therefore, if the quantity of removable contamination does not exceed the limiting value of .3 curies, (676 kg uranium) the radiological dose to persons off-site should not exceed 1 rem and health effects due to uranium toxicity should be negligible.

To develop a measure of the relationship of the level contamination with the surface area contaminated, consider a removable surface contamination level of 10,000 dpm/100 cm$^2$. Discussions with Health Physics personnel indicates that this level is unlikely to be found at the K-25 Site, except in small isolated areas as indicated by survey data (Reference 11). The surface area required to exceed the most limiting value would be:

$$A = \frac{(0.3\ Ci)(2.2 \times 10^{12}\ dpm/Ci)}{\left(\frac{10{,}000\ dpm}{100\ cm^2}\right)\left(930\ \frac{cm^2}{ft^2}\right)}$$

$$= 7{,}000{,}000\ ft^2$$

The limiting values in 10 CFR 30.72 are based on calculations described in NUREG-1140 (Reference 10). The resulting radiological/toxic effects are calculated for an off-site receptor at 100 m.

Nuclear Criticality

The potential for nuclear criticality is addressed by conservatively considering <u>all</u> of the removable surface contamination to be deposited into a single location due to some initiating event (e.g., sprinkler activation or roof failure during a rainstorm). The total mass of $^{235}U$ can be determined from

$$mass\ of\ U\text{-}235\ (gm) = \left(\frac{QE/100}{S_A}\right)$$

where

| | | |
|---|---|---|
| Q | = | radioactivity, Ci |
| $S_A$ | = | $(0.4 + 0.38E + 0.0034E^2)\ 10^{-6}$, Ci/gm of uranium (Reference 1) |
| E | = | grams of $^{235}U$/g of uranium (%) |

The mass limit per DOE Order 5480.5 (Reference 9) at which a criticality alarm system is required is 700 gm. Thus, criticality is assumed not credible for a total radioactivity level less than

$$Q = \left[\frac{700\ S_A}{E/100}\right]$$

$$Q = 0.07\left[\frac{.4 + .38E + .0034E^2}{E}\right]$$

For a removable surface contamination level of 10,000 dpm/100 cm², the corresponding area is

$$A = \frac{Q(2.2 \times 10^{12}\ dpm/Ci)}{\left[\dfrac{10.000\ dpm}{100\ cm^2}\right]\left[930\ \dfrac{cm^2}{ft^2}\right]}$$

$$A = 23.656.000\ Q$$

$$A = 1.656.000\left[\frac{0.4 + 0.38E + 0.0034E^2}{E}\right]$$

At the K-25 Site, the enrichment commonly ranges from 0.2% to 5% $^{235}U$. For 5% $^{235}U$, criticality is not credible when the contaminated surface area does not exceed

$$A = 790,000\ ft^2$$

On-Site Radiological/Chemical

Occupational worker exposure to radiation is considered to be adequately controlled by the application of guidelines required by DOE 5480.11. This evaluation will consider the potential effects of air-borne dispersion of widespread, but relatively low-level, surface contamination within a facility and the effects of releases resulting from events causing airborne dispersion of contamination to locations outside of the building.

To assess the effects within a building, it will be assumed that all of the removable surface contamination in a facility is instantaneously made airborne and spread uniformly through the volume of the building. Because the distribution of employees in the building is not generally available, the exposure time will be calculated as the time to exit from the center of the building unless it is determined that points within the building lie at a point more distant. In that event, the greater distance will be used to calculate exposure time. Both radiological effects and chemical toxicity effects will be considered, but chemical toxicity will be limiting as long as uranium is the only contaminant material of concern. Unlike the off-site and criticality effects, there will be a lower limit on the surface area derived from this evaluation, and thus, the potential hazard requires individual evaluation. The derived value and the 5480.11 imposed limits must be considered to determine whether further analysis is required. If the restrictions on building occupancy imposed by 5480.11 compliance would preclude occupancy at any level of surface contamination determined to present a hazard, then there is no need to consider this event.

For on-site exposure outside of the facility, the exposure is calculated for a cloud of the removable contaminant generated as a puff dispersing from the source in the event of a catastrophic failure such as a building collapse. If a significant portion of the fixed contamination is in combustible materials then the potential exists for release of the fixed plus removable contamination in the event of a fire. The nature of a fire tends to cause most of the combustion products and the contaminants to rise with the smoke plume and then be distributed as an elevated release. Thus, the case for the drifting cloud will be the bounding result for facilities persons within the 100 m range of consideration.

This approach is considered to be conservative because it is extremely unlikely that all removable surface contamination could be made airborne. Also, the exposure time considered for exit would be less for points near the wall but that vicinity is likely to have higher concentrations than the average, so that the total inhalation potential is no greater than that for the average. This is considered to be bounding for a fire because the nature of a fire would cause the contamination to become airborne over a substantial period of time. Building occupants are expected to make an orderly evacuation of the facility and not remain for an extended period of time in a fire event. Fire fighters are provided with appropriate protective gear and training in its use so that undue internal exposure is not expected to result from fire fighting efforts in the facility.

A simple evaluation is recommended for the evaluation of close-in receptors outside of the building. For this model, the area within 100 m of the facility should be considered to have the same concentration as that determined within the facility. The potential effects on persons located within that range are considered to be bounded by the dose received by an individual who remains stationary as the cloud passes at the rate of 1 m/s, representing F class stability, but assuming no mixing or dilution in this range. For the purposes of determining the exposure time, the cloud shall be assumed to travel in the same shape as the original building in a direction perpendicular to the building face having the smaller cross section.

**Conclusions**

For removable "nonwork" surface contamination, if the contaminated surface area is less than 790,000 $ft^2$ and 10,000 dpm/100 $cm^2$, then there is no potential for criticality. For facilities with a contaminated surface area greater than 790,000 $ft^2$, the contamination level must be correspondingly lower than 10,000 dpm/100 $cm^2$. Similarly, for facilities with a contamination level higher than 10,000 dpm/100 $cm^2$, the surface area must be lower. Because of the limited assay range evaluated, the criticality evaluation is only applicable to facilities having contamination at assays not exceeding 5% $^{235}U$.

For areas not requiring criticality consideration, the 7,000,000 $ft^2$ value may be used for evaluation of the surface contamination for both on-site and off-site effects. For areas greater than 7,000,000 $ft^2$, the allowable surface contamination must be proportionally smaller to meet the criteria of this approach. The situation for areas smaller than 7,000,000 $ft^2$ is that the allowable surface contamination levels may be proportionally larger than 10,000 dpm/100$cm^2$ with one notable exception. Off-site concerns do not reflect the effects of the initial concentration of the source prior to dispersion. It is possible that the larger surface concentrations allowable for smaller areas may result in potential hazard to employees. Thus, an evaluation of the potential for the contamination, when dispersed over the building volume, to exceed the threshold values for reversible health effects, either chemical or radiological must be made. This same consideration applies to persons outside of the facility but within 100 m.

It is important to note that this conclusion is valid only for "nonwork" surfaces. Radioactive materials and contaminated process equipment must be evaluated separately.

This is intended as a screening technique to allow identification of facilities which do not need additional analysis for contamination. A "second-pass" analysis may be used to refine such calculations if this conservative technique screens the facility in, but such a conclusion does not appear warranted.

References

1. Central Safety Evaluation Team. CSET-2. *Safety Analysis Report Update Program. Hazard Screening Application Guide.* December 1991.

2. DOE Order 5480.11. *Radiation Protection for Occupational Workers.* July 20. 1989.

3. ORO "Radiation Contamination Control Policy," June. 1989.

4. Standard Practice Procedure. SPP-804. *Contamination and Radiation Exposure Control Guides and Standards,* Martin Marietta Energy Systems. Inc.. March 1991.

5. Standard Practice Procedure. SPP-808. *Notification and Reporting of Radiological Occurrences,* Martin Marietta Energy Systems. Inc.. April 1991.

6. Interim Health Physics Department Guidance. *Basic Contamination Survey Techniques.* Martin Marietta Energy Systems. Inc.. November 1990.

7. Standard Practice Procedure. SPP-609. *Maintaining Exposures to Hazardous Materials and Radiation to Levels that are ALARA.* Martin Marietta Energy Systems. Inc.. January 1991.

8. Meeting minutes from CSETWG meeting of 3/13/91 (Attachment 3).

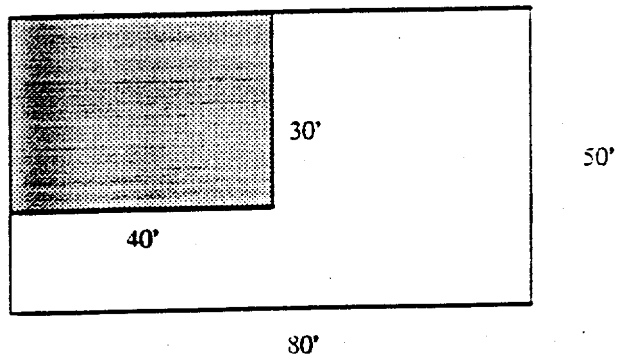
9. DOE Order 5480.5. *Safety of Nuclear Facilities.* September 23. 1986.

10. NUREG-1140. *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees.* January 1990.

11. A. Semanis. private communication. June 1991.

*Example 1:*

Contamination area - 20,000 dpm $\alpha$/100 $cm^2$




Height = 20'

$$A = \frac{(20{,}000\ dpm/100\ cm^2)}{(2.22 \times 10^{12}\ dpm/Ci)} (40\ ft \times 30\ ft) \left(929\ \frac{cm^2}{ft^2}\right) = 1.0 \times 10^{-4}\ Ci$$

$$C = \frac{A}{V} = \frac{(1 \times 10^{-4}\ Ci)(35.3\ ft^3/m^3)}{(50\ ft \times 80\ ft \times 20\ ft)} = 4.4 \times 10^{-8} \left(\frac{Ci}{m^3}\right) = 4.4 \times 10^{-8} \left(\frac{\mu c}{ml}\right)$$

$$C_{5480.11} = 2 \times 10^{-11} \left(\frac{\mu\ Ci}{ml}\right)$$

The concentration in 5480.11 is based on a 2000 hr work year. The equivalent exposure allowed is:

$$C_{allowed} = 2 \times 10^{-11} \left(\frac{2000}{t_e}\right)$$

The longest evacuation route is a diagonal across the length of the building.

Thus,

$$t_e = \frac{(\sqrt{(80)^2 + (50)^2}\ ft)(0.305\ m/ft)}{(1.5\ m/sec)(3600\ sec/hr)} = 0.0053\ hr$$

and

$$C_{allowed} = 7.5 \times 10^{-6} \left(\frac{\mu Ci}{ml}\right)$$

# APPENDIX C

## K-25 SITE CONSEQUENCE DETERMINATION FOR A RELEASE OF REMOVABLE SURFACE CONTAMINATION

# K-25 SITE CONSEQUENCE DETERMINATION FOR A RELEASE OF REMOVABLE SURFACE CONTAMINATION

## I. Introduction and Objectives

### A. Statement of Problem

Surface contamination above the screening levels in CSET-2 is a common hazard at the K-25 Site. This is not considered a Standard Industrial Hazard and must go through a formal Hazard Screening Analysis. However, contaminated surfaces are identified, characterized, and controlled by the K-25 Site procedures and maintained at ALARA levels such that the consequences from potential exposures from "non-work" surfaces are expected to pose no appreciable health consequences. "Non-work" surfaces are defined as:

> *Floors, walls, ceilings, walkways, external surfaces of process enclosures (cell housings, hot cells, glove boxes, etc.), handrails, windows, electrical utilities, HVAC components, and plumbing fixtures. Also, for the purpose of this evaluation, "non-work" surfaces include furniture surfaces such as chairs, desks, tables, stools, countertops, lockers, benches, cabinets, vending machines, and appliances. (Reference 3)*

A conservative evaluation of contaminated "non-work" surfaces for Hazard Screening is provided. Facilities determined to require further analysis may well be determined to pose no significant hazard once a specific analysis is completed.

**There are three concerns associated with removable surface contamination: (1) the atmospheric release of radiation which might affect persons off-site, (2) the potential for a nuclear criticality as the result of the collection of removable surface contamination washed from surfaces and deposited into a single location, and (3) the potential effects to persons on-site. Only the potential effects to persons on-site will be evaluated in this calculation.**

### B. Background

As a result of processes involving radioactive materials, surface contamination is present in many areas of the K-25 Site. Radiation protection for workers is regulated by DOE Order 5480.11 (Reference 2) and ORO Radioactive Contamination Control Policy (Reference 3). Energy Systems Standard Practice Procedures 804 and 808 (References 4 and 5) and the K-25 Site Interim Health Physics Guide INT-0010 (Reference 6) define survey, control and reporting criteria which implement the requirements of the DOE Order and ORO Policy. Energy Systems Standard Practice Procedure 609 (Reference 7) implements an ALARA program which ensures that contamination levels are minimized with respect to the potential exposure of occupational workers.

Contamination may be fixed or removable. Fixed contamination is impregnated within the material and cannot be removed by ordinary means. such as wiping or washing. Thus. it is not considered a significant hazard to the public or general employee. Exposure of occupational workers to fixed contamination. when controlled to industry standards. is well within the levels of a Negligible Hazard (Reference 8).

Removable contamination represents a more significant exposure to occupational workers since it may become airborne by mechanical impact or air currents. In order to maintain exposure ALARA. every effort is made to minimize removable contamination. However. because of the potential for an airborne release due to a catastrophic event (e.g., fire. tornado. explosion) or a criticality incident. removable "non-work" surface contamination shall be evaluated for a worst case scenario.

## II. Basis for Design

### A. Design Input and Source

Information regarding the levels of removable surface contamination was obtained from recent surveys completed by Health Physics.

### B. References

1. Hazard Screening Application Guide, CSET-2. 1990.

2. Radiation Protection for Occupational Workers, DOE Order 5480.11. U.S. Department of Energy, Washington. D. C.. 1989.

3. Radiation Contamination Control Policy, ORO. 1989.

4. Contamination and Radiation Exposure Control Guides and Standards, Martin Marietta Energy Systems. Inc. Standard Practice Procedure 804. 1991.

5. Notification and Reporting of Radiological Occurrences, Martin Marietta Energy Systems. Inc. Standard Practice Procedure 808. 1991.

6. Basic Contamination Survey Techniques, Martin Marietta Energy Systems. Inc. Interim Health Physics Department Guidance. 1990.

7. Maintaining Exposures to Hazardous Materials and Radiation to Levels that are ALARA, Martin Marietta Energy Systems. Inc. Standard Practice Procedure 609. 1991.

8. Meeting minutes from CSETWG meeting of March 13. 1991.

9. Safety of Nuclear Facilities. DOE Order 5480.5. U.S. Department of Energy, Washington. D. C.. 1986.

10. A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licenses, NUREG-1140. 1990.

11. Internal Dose-Rate Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, U.S. Department of Energy, Washington. D.C., July 1988.

12. R. A. Just and V. S. Emler, Generic Report on Health Effects for the U. S. Gaseous Diffusion Plants, K/D 5050, Section VIII, Part 1, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee. 1984.

13. Microsoft EXCEL, Version 2.1, Microsoft Corporation, Redmond, Washington. 1989.

B. Assumptions

1. The removable surface contamination is uniformly distributed over the contaminated area of the facility.

2. The contaminated area of the facility is assumed to consist of floors, ceiling and walls. Since a building will not have the same contamination level on all these surfaces, this is adequate.

3. The material of interest is uranium which consists of 5% $^{235}U$, 0.05% $^{234}U$ and 94.95% $^{238}U$.

4. The ceiling height of the facility is 10 ft.

5. To estimate the effects within a facility it is assumed that all of the removable surface contamination in the facility is instantaneously made airborne and spread uniformly throughout the volume of the facility.

6. The individual inside the facility is assumed to be exposed to the concentration without any respiratory protection for the time it takes to walk out of the facility at a walking speed of 1 m/s.

7. The closest individuals outside the facility are assumed to be on-site within a distance of 100 m.

8. The individual outside the facility is assumed to remain stationary as the cloud passes at the rate of 1 m/s, representing F class stability, but with no mixing or dilution in this range.

9. The region within 100 m of the facility is assumed to have the same concentration as that determined within the facility.

10. The breathing rate is assumed to be $3.33 \times 10^{-4}$ $m^3/s$.

C. Methods to be Used

1. Dispersion Analysis

The methods of Hazard Screening Application Guide CSET-2, Appendix E, "Consequence Calculation Methodology" will be used to determine the concentration-time integrals and the radiation dose for a release of removable surface contamination from a facility.

The expression for the amount of airborne material for an instantaneous release is

$$Q = f\,M \tag{1}$$

where

Q is the amount of material which becomes airborne, g,
f is the release fraction, and
M is the material available for release, g.

The concentration-time integral for an instantaneous release for the close-in estimate is given by

$$I = Q\,t_M/V \tag{2}$$

where

I is the concentration-time integral, mg s/m$^3$,
V is the mixing volume, m$^3$,
$t_M$ is the exposure time.

The concentration-time integrals for the large distance estimate for the instantaneous release is given by

$$I = Q\,(\pi\,u\,A_y\,A_z)^{-1} \tag{3}$$

where

u is the wind speed, m/s, and
$A_y$ and $A_z$ are the cross-wind horizontal and vertical dispersion coefficients, respectively, m.

The values for the dispersion coefficients in the above expressions are derived from continuous point source values recommended by Briggs for level ground and open-country conditions (Hanna et al. 1982, Table 4.5, p 30). The values are a function of the downwind distance and the atmospheric stability class. There are six stability classes ranging from A (unstable) to F (very stable). For ground level releases the F stability will always yield the highest maximum concentrations and concentration-time integrals, and these values will decrease with increasing distance from the release. Examination of suggested values for instantaneous releases (Slade, 1968, pp 173-175) indicates that a rough approximation for the instantaneous vertical dispersion coefficient is to set it equal to the corresponding continuous value. It also implies that the instantaneous values for the cross-wind, horizontal coefficients are about equal to half the horizontal continuous value. The expressions for the continuous dispersion values for F stability are

$$A_y = (0.04\,x)(1.0 + 0.0001\,x)^{-1/2} \quad (4)$$

$$A_z = (0.016\,x)(1.0 + 0.0003\,x)^{-1} \quad (5)$$

where x is the downwind distance in meters.

For radionuclides released to the air, inhalation is the principal pathway for entering the body. An expression for calculating the internal radiation dose due to inhalation is

$$D_s = B\,D_f\,I \quad (6)$$

where

$D_s$ is the 50-year committed effective dose equivalent (C.E.D.E.), rem.
B is the inhalation rate, $m^3/s$, and
$D_f$ is the radiation dose conversion factor, rem/$\mu$Ci.

## III. Analysis and/or Calculations

### A. Analysis

The potential effects to persons on-site are evaluated. In actuality the chemical toxicity of uranium is such that chemical toxicity is the controlling factor in setting the exposure limits to airborne uranium. Thus, the evaluations for the effects of airborne uranium presented will consider limits resulting from the chemical toxicity as the bounding condition.

While health effects due to radiation are generally characterized as a function of the dose received per mass unit, expressed in rems, the typical measure of contamination available from health physics surveys is given in disintegrations per minute (dpm) per 100 $cm^2$ of surface area. Thus, the calculations are presented in terms of the contamination measures.

Occupational worker exposure to radiation is considered to be adequately controlled by the application of guidelines required by DOE Order 5480.11. This evaluation will consider the potential effects of airborne dispersion of widespread, but relatively low-level, surface contamination within a facility and the effects of releases resulting from events causing airborne dispersion of contamination to locations inside and outside of the facility.

To assess the effects within a facility it is assumed that all of the removable surface contamination in a facility is instantaneously made airborne and spread uniformly throughout the volume of the building. Both radiological and chemical toxicity effects will be considered, but chemical toxicity will be limiting as long as uranium is the only contaminant material of concern.

For on-site exposure outside of the facility the exposure is calculated for a cloud of the removable contaminant generated as a puff dispersing from the source in the event of a catastrophic failure such as a building collapse. If a significant portion of the fixed contamination is in combustible materials then the potential exists for a release of the fixed plus removable contamination in the event of a fire. The nature of a fire tends to cause most of the combustion products and the contaminants to rise with the smoke plume and then be distributed as an elevated release. Thus, the case for the drifting cloud will be the bounding result for facilities with persons within the 100 m range of consideration.

For the evaluation of close-in receptors outside of the facility the area within 100 m of the facility is considered to have the same concentration as that determined within the facility. The potential effects on persons located within that range are considered to be bounded by the dose received by an individual who remains stationary as the cloud passes at the rate of 1 m/s, representing F class stability, but assuming no mixing or dilution in this range. For the purpose of determining the exposure time the cloud shall be assumed to travel in the same shape as the original building in a direction perpendicular to the building face having the smaller cross section.

The effects to off-site individuals are addressed in Appendix B of the Hazard Screening Document, Evaluation of Surface Contamination at the K-25 Site (Reference 1) and will not be analyzed here. However, an example of the dependecy of the quanity of material released on the contaminated area and on the contamination level is given in Section III.B.3 for illustrative purposes.

B. Calculations

1. Dispersion Analysis - Receptor Inside the Facility

**To assess the effects within a facility it is assumed that all of the removable surface contamination in a facility is instantaneously made airborne and spread uniformly throughout the volume of the building.** When the contaminant level is given in units of dpm/100 cm², the amount of material available for release can be expressed by

$$M = L\,A_B \tag{7}$$

$$A_B = 2\,A_F + A_W \tag{8}$$

where L is the contaminant level, dpm/100 cm².
$A_B$ is the total contaminated surface area (e.g., the surface area of the building), m².
$A_F$ is the surface area of the floor and/or ceiling, m², and
$A_W$ is the surface area of the walls.

It can be shown that if the height of the walls is $\leq$ 0.25 the length of the shortest side of the building, then the surface area of the building is:

$$A_B \leq 3\,A_F \tag{9}$$

Therefore, for a release fraction of 1.0 and a building sized as described above the quantity released can be expressed as:

$$Q = 3\ L\ A_F \tag{10}$$

The volume into which the material is instantaneously made airborne and spread uniformly is

$$V = A_F\ h \tag{11}$$

where h is the ceiling height, m.

Substituting into equation (2) the concentration-time integral becomes

$$I = 3\ L\ A_F\ t_M/(A_F\ h)$$

$$I = 3\ L\ t_M/h \tag{12}$$

As can be seen by Equation (12), the concentration-time integral is not a function of area, but is a function of contaminant level, exposure time and ceiling height. It should be noted that for ceiling heights greater than 0.25 the length of the shortest side of the building Equation (12) is not valid, and the actual building area will have to be used. For a constant ceiling height (assumption 3) and a specific contaminant level the concentration-time integral is just a function of exposure time. For the individual inside the facility the exposure time is the time it takes to walk out of the building. This may be found by dividing the distance of the shortest route to the nearest exit by the walking speed. The dose is determined by Equation (6).

2. Dispersion Analysis - Close-in Receptor Outside the Facility

For the evaluation of close-in receptors outside of the facility the area within 100 m of the facility is considered to have the same concentration as that determined within the facility. The potential effects on persons located within that range are considered to be bounded by the dose received by an individual who remains stationary as the cloud passes at the rate of 1 m/s, representing F class stability, but assuming no mixing or dilution in this range. For the purpose of determining the exposure time the cloud shall be assumed to travel in the same shape as the original building in a direction perpendicular to the building face having the smaller cross section.

Since the volume to which the close-in receptor outside of the facility is exposed is the same as that to which the receptor inside of the facility is exposed, the equations remain the same. However, the manner in which the exposure time is determined is different. For the close-receptor outside of the facility the exposure time is found by dividing the longest dimension of the building by the wind speed.

3. Dispersion Analysis - Distant Receptor Outside the Facility

To determine the potential effects to the distant receptor (i.e., an individual located outside of the facility at a distance of greater than 100 m) the Gaussian dispersion model may be used [Equations (3), (4), and (5)]. The amount of material released is determined by Equation (10).

Thus, the amount of material released is dependent on the contamination level and the surface area. The amount of material released from a facility with a low contamination level and a large surface area could be the same as that released from a facility with a high contamination level and a small surface area. For example:

$$Q = (10{,}000\ dpm/100\ cm^2)(10^4\ cm^2/m^2)(30{,}000\ m^2) = 3 \times 10^{10}\ dpm$$

$$Q = (100{,}000\ dpm/100\ cm^2)(10^4\ cm^2/m^2)(3{,}000\ m^2) = 3 \times 10^{10}\ dpm$$

Tables generated using EXCEL for both the inside receptor and the close-in outside receptor are presented on the pages following this calculation. The first page of the tables gives pertinent data for the necessary calculations, the second page of the tables shows maximum exposure times for the various contamination levels for negligible radiological and toxic health effects, the floor area which would yield negligible health effects for the various contamination levels. The third and fourth pages of the tables show the concentration-time integral and the radiation dose for various exposure times and various contamination levels for a facility which has removable surface contamination.

## IV. Conclusions and/or Recommendations

A. **The results given in the table show that for both the individual inside and outside the facility, the maximum exposure time for a dose $\leq$ 10 rem varies from 5.6 s for a contamination level of 1,000,000 dpm/100 cm$^2$ to 5,600 s for a contamination level of 1,000 dpm/100 cm$^2$.**

B. Just and Emler (1984) report air concentrations of soluble uranium, as functions of exposure time, that result in health effects due to chemical toxicity. These values may be conservatively applied to insoluble uranium. For exposures less than thirty minutes no health effects occur at concentration-time integrals less than 39 g s/m$^3$, possible mild (reversible) health effects occur at concentration-time integrals between 39 g s/m$^3$ and 75 g s/m3, and renal injury occurs at concentration-time integrals greater than 75 g s/m$^3$. The concentration-time integrals vary similarly to the radiation effects with a maximum exposure time of 10 s for a contamination level of 1,000,000 dpm/100 cm$^2$ to 1.68 x 10$^3$ s for a contamination level of 1,000 dpm/100 cm$^2$.

C. The technique for using this calculation can be accomplished in two ways. Table 2 of the EXCEL pages can be used to determine if the facility under consideration is within the boundaries set by this calculation. For example for a facility with a contamination level of 10,000 dpm/100 cm$^2$ if the individual inside the facility can exit within 313 s, the bounding toxic effects would be negligible. For the person outside the facility toxic effects would be negligible if the building is $\leq$ 313 m (313 s x 1.0 m/s = 313 m).

Using Table 3 of the EXCEL pages, if the receptor inside the facility can exit within 90 s, and the contamination level is 10,000 dpm/100 $cm^2$, the concentration-time integral is 11.2 g s/$m^3$. This is below the 39 g s/$m^3$ considered to be the lower bound for the region of negligible health effects. Alternatively, for the receptor outside the facility, the concentration-time integral is 49.9 g s/$m^3$ for a contamination level of 10,000 dpm/100 $cm^2$ and a building length of 400 m (400 s x 1.0 m/s = 400 m). Since this is greater than 39 g s/$m^3$ but less than 75 g s/$m^3$ the health effects would be reversible.

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Health Effects from Release of Removable Surface Contamination | | | | | |
| On-site inside the facility and within 100 m outside the facility | | | | | |
| | | | | | |
| Table 1. Assumptions and Data | | | | | |
| | | | | | |
| Examples of removable surface contamination for use in the calculations. | | | | | |
| 1000 | dpm/100 sq cm | | 4.50e-08 | Ci/sq m | |
| 10000 | dpm/100 sq cm | | 4.50e-07 | Ci/sq m | |
| 100000 | dpm/100 sq cm | | 4.50e-06 | Ci/sq m | |
| 1000000 | dpm/100 sq cm | | 4.50e-05 | Ci/sq m | |
| | | | | | |
| Approximate Ceiling Height | 10 ft | (3.05 m) | | | |
| | | | | | |
| Isotope | Enrichment (%) | Specific Activity (Ci/g) | Sa per % Enrichment (Ci/g) | Internal Dose Conv Factor (rem/Ci) | Df per % Enrichment (rem/Ci) |
| U-234 | 0.05% | 6.25e-03 | 3.13e-06 | 1.30e+08 | 6.50e+04 |
| U-235 | 5.00% | 2.16e-06 | 1.08e-07 | 1.20e+08 | 6.00e+06 |
| U-238 | 94.95% | 3.37e-07 | 3.20e-07 | 1.20e+08 | 1.14e+08 |
| Total | 100.00% | | 3.55e-06 | | 1.20e+08 |
| | | | | | |
| Concentration-time integral, I = Q tm/V, Q = L Ab V = Af h Ab = 3 Af | | | | | |
| | | | | | |
| Ia (activity) = (X dpm/100 sq cm) tm/h | | | | Dose = B Df Ia | |
| | | | | | |
| Im (mass) = Ia/Sa | | | | | |
| | | | | | |
| The exposure time for a 10 rem dose assuming 100% contamination is | | | | | |
| | | | | | |
| | tm = Ds h/(3 B Df L) | | | | |
| | | | | | |
| The exposure time for Im = 39 g s/cu m, 75 g s/cu m, and 2100 g | | | | | |
| s/cu m, assuming 100% contamination is | | | | | |
| | | | | | |
| | tm = Im Sa h/(3 L) | | | | |

| G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|
| Table 2. Inside receptor and receptor outside within 100 m | | | | | | |
| | | | | | | |
| Contamination Level/100 sq cm | | | 1E+03 dpm | 1E+04 dpm | 1E+05 dpm | 1E+06 dpm |
| | Radiological Effects | | | | | |
| Exp time for 10 rem dose, s | | | 5644 | 564 | 56 | 6 |
| | Toxic Effects | | | | | |
| Exp time for Im = 39 g s/cu m, s | | | 3125 | 313 | 31 | 3 |
| Exp time for Im = 75 g s/cu m, s | | | 6010 | 601 | 60 | 6 |
| Exp time for Im = 2100 g s/cu m, s | | | 1.68e+05 | 1.68e+04 | 1683 | 168 |
| | | | | | | |

| N | O | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|
| Table 3. Concentration time-integrals in terms of activity and mass and dose | | | | | | | |
| | | | | | | | |
| Exp Time (s) | 1,000 dpm/100 sq cm | | | | 10,000 dpm/100 sq cm | | |
| | Ia (Ci s/cu m) | Im (g s/cu m) | Ds (rem) | | Ia (Ci s/cu m) | Im (g s/cu m) | Ds (rem) |
| 1 | 4.43e-08 | 1.25e-02 | 1.77e-03 | | 4.43e-07 | 1.25e-01 | 1.77e-02 |
| 2 | 8.87e-08 | 2.50e-02 | 3.54e-03 | | 8.87e-07 | 2.50e-01 | 3.54e-02 |
| 3 | 1.33e-07 | 3.74e-02 | 5.32e-03 | | 1.33e-06 | 3.74e-01 | 5.32e-02 |
| 4 | 1.77e-07 | 4.99e-02 | 7.09e-03 | | 1.77e-06 | 4.99e-01 | 7.09e-02 |
| 5 | 2.22e-07 | 6.24e-02 | 8.86e-03 | | 2.22e-06 | 6.24e-01 | 8.86e-02 |
| 6 | 2.66e-07 | 7.49e-02 | 1.06e-02 | | 2.66e-06 | 7.49e-01 | 1.06e-01 |
| 7 | 3.10e-07 | 8.73e-02 | 1.24e-02 | | 3.10e-06 | 8.73e-01 | 1.24e-01 |
| 8 | 3.55e-07 | 9.98e-02 | 1.42e-02 | | 3.55e-06 | 9.98e-01 | 1.42e-01 |
| 9 | 3.99e-07 | 1.12e-01 | 1.59e-02 | | 3.99e-06 | 1.12e+00 | 1.59e-01 |
| 19 | 8.42e-07 | 2.37e-01 | 3.37e-02 | | 8.42e-06 | 2.37e+00 | 3.37e-01 |
| 20 | 8.87e-07 | 2.50e-01 | 3.54e-02 | | 8.87e-06 | 2.50e+00 | 3.54e-01 |
| 30 | 1.33e-06 | 3.74e-01 | 5.32e-02 | | 1.33e-05 | 3.74e+00 | 5.32e-01 |
| 40 | 1.77e-06 | 4.99e-01 | 7.09e-02 | | 1.77e-05 | 4.99e+00 | 7.09e-01 |
| 50 | 2.22e-06 | 6.24e-01 | 8.86e-02 | | 2.22e-05 | 6.24e+00 | 8.86e-01 |
| 60 | 2.66e-06 | 7.49e-01 | 1.06e-01 | | 2.66e-05 | 7.49e+00 | 1.06e+00 |
| 70 | 3.10e-06 | 8.73e-01 | 1.24e-01 | | 3.10e-05 | 8.73e+00 | 1.24e+00 |
| 80 | 3.55e-06 | 9.98e-01 | 1.42e-01 | | 3.55e-05 | 9.98e+00 | 1.42e+00 |
| 90 | 3.99e-06 | 1.12e+00 | 1.59e-01 | | 3.99e-05 | 1.12e+01 | 1.59e+00 |
| 100 | 4.43e-06 | 1.25e+00 | 1.77e-01 | | 4.43e-05 | 1.25e+01 | 1.77e+00 |
| 200 | 8.87e-06 | 2.50e+00 | 3.54e-01 | | 8.87e-05 | 2.50e+01 | 3.54e+00 |
| 300 | 1.33e-05 | 3.74e+00 | 5.32e-01 | | 1.33e-04 | 3.74e+01 | 5.32e+00 |
| 400 | 1.77e-05 | 4.99e+00 | 7.09e-01 | | 1.77e-04 | 4.99e+01 | 7.09e+00 |
| 500 | 2.22e-05 | 6.24e+00 | 8.86e-01 | | 2.22e-04 | 6.24e+01 | 8.86e+00 |
| 600 | 2.66e-05 | 7.49e+00 | 1.06e+00 | | 2.66e-04 | 7.49e+01 | 1.06e+01 |
| 700 | 3.10e-05 | 8.73e+00 | 1.24e+00 | | 3.10e-04 | 8.73e+01 | 1.24e+01 |
| 800 | 3.55e-05 | 9.98e+00 | 1.42e+00 | | 3.55e-04 | 9.98e+01 | 1.42e+01 |
| 900 | 3.99e-05 | 1.12e+01 | 1.59e+00 | | 3.99e-04 | 1.12e+02 | 1.59e+01 |
| 1000 | 4.43e-05 | 1.25e+01 | 1.77e+00 | | 4.43e-04 | 1.25e+02 | 1.77e+01 |
| 1500 | 6.65e-05 | 1.87e+01 | 2.66e+00 | | 6.65e-04 | 1.87e+02 | 2.66e+01 |
| 1800 | 7.98e-05 | 2.25e+01 | 3.19e+00 | | 7.98e-04 | 2.25e+02 | 3.19e+01 |
| 2000 | 8.87e-05 | 2.50e+01 | 3.54e+00 | | 8.87e-04 | 2.50e+02 | 3.54e+01 |

| V | W | X | Y | Z | AA | AB | AC |
|---|---|---|---|---|---|---|---|
| **Table 3. (cont:d) Concentration time-integrals in terms of activity and mass and dose** | | | | | | | |
| | | | | | | | |
| Exp Time (s) | 100,000 dpm/100 sq cm | | | | 1,000,000 dpm/100 sq cm | | |
| | Ia (Ci s/cu m) | Im (g s/cu m) | Ds (rem) | | Ia (Ci s/cu m) | Im (g s/cu m) | Ds (rem) |
| 1 | 4.43e-06 | 1.25e+00 | 1.77e-01 | | 4.43e-05 | 1.25e+01 | 1.77e+00 |
| 2 | 8.87e-06 | 2.50e+00 | 3.54e-01 | | 8.87e-05 | 2.50e+01 | 3.54e+00 |
| 3 | 1.33e-05 | 3.74e+00 | 5.32e-01 | | 1.33e-04 | 3.74e+01 | 5.32e+00 |
| 4 | 1.77e-05 | 4.99e+00 | 7.09e-01 | | 1.77e-04 | 4.99e+01 | 7.09e+00 |
| 5 | 2.22e-05 | 6.24e+00 | 8.86e-01 | | 2.22e-04 | 6.24e+01 | 8.86e+00 |
| 6 | 2.66e-05 | 7.49e+00 | 1.06e+00 | | 2.66e-04 | 7.49e+01 | 1.06e+01 |
| 7 | 3.10e-05 | 8.73e+00 | 1.24e+00 | | 3.10e-04 | 8.73e+01 | 1.24e+01 |
| 8 | 3.55e-05 | 9.98e+00 | 1.42e+00 | | 3.55e-04 | 9.98e+01 | 1.42e+01 |
| 9 | 3.99e-05 | 1.12e+01 | 1.59e+00 | | 3.99e-04 | 1.12e+02 | 1.59e+01 |
| 19 | 8.42e-05 | 2.37e+01 | 3.37e+00 | | 8.42e-04 | 2.37e+02 | 3.37e+01 |
| 20 | 8.87e-05 | 2.50e+01 | 3.54e+00 | | 8.87e-04 | 2.50e+02 | 3.54e+01 |
| 30 | 1.33e-04 | 3.74e+01 | 5.32e+00 | | 1.33e-03 | 3.74e+02 | 5.32e+01 |
| 40 | 1.77e-04 | 4.99e+01 | 7.09e+00 | | 1.77e-03 | 4.99e+02 | 7.09e+01 |
| 50 | 2.22e-04 | 6.24e+01 | 8.86e+00 | | 2.22e-03 | 6.24e+02 | 8.86e+01 |
| 60 | 2.66e-04 | 7.49e+01 | 1.06e+01 | | 2.66e-03 | 7.49e+02 | 1.06e+02 |
| 70 | 3.10e-04 | 8.73e+01 | 1.24e+01 | | 3.10e-03 | 8.73e+02 | 1.24e+02 |
| 80 | 3.55e-04 | 9.98e+01 | 1.42e+01 | | 3.55e-03 | 9.98e+02 | 1.42e+02 |
| 90 | 3.99e-04 | 1.12e+02 | 1.59e+01 | | 3.99e-03 | 1.12e+03 | 1.59e+02 |
| 100 | 4.43e-04 | 1.25e+02 | 1.77e+01 | | 4.43e-03 | 1.25e+03 | 1.77e+02 |
| 200 | 8.87e-04 | 2.50e+02 | 3.54e+01 | | 8.87e-03 | 2.50e+03 | 3.54e+02 |
| 300 | 1.33e-03 | 3.74e+02 | 5.32e+01 | | 1.33e-02 | 3.74e+03 | 5.32e+02 |
| 400 | 1.77e-03 | 4.99e+02 | 7.09e+01 | | 1.77e-02 | 4.99e+03 | 7.09e+02 |
| 500 | 2.22e-03 | 6.24e+02 | 8.86e+01 | | 2.22e-02 | 6.24e+03 | 8.86e+02 |
| 600 | 2.66e-03 | 7.49e+02 | 1.06e+02 | | 2.66e-02 | 7.49e+03 | 1.06e+03 |
| 700 | 3.10e-03 | 8.73e+02 | 1.24e+02 | | 3.10e-02 | 8.73e+03 | 1.24e+03 |
| 800 | 3.55e-03 | 9.98e+02 | 1.42e+02 | | 3.55e-02 | 9.98e+03 | 1.42e+03 |
| 900 | 3.99e-03 | 1.12e+03 | 1.59e+02 | | 3.99e-02 | 1.12e+04 | 1.59e+03 |
| 1000 | 4.43e-03 | 1.25e+03 | 1.77e+02 | | 4.43e-02 | 1.25e+04 | 1.77e+03 |
| 1500 | 6.65e-03 | 1.87e+03 | 2.66e+02 | | 6.65e-02 | 1.87e+04 | 2.66e+03 |
| 1800 | 7.98e-03 | 2.25e+03 | 3.19e+02 | | 7.98e-02 | 2.25e+04 | 3.19e+03 |
| 2000 | 8.87e-03 | 2.50e+03 | 3.54e+02 | | 8.87e-02 | 2.50e+04 | 3.54e+03 |

# APPENDIX D

## CONSEQUENCE DETERMINATION FOR A RELEASE OF NICKEL POWDER IN BUILDING K-1037

APPENDIX D

# CONSEQUENCE DETERMINATION FOR A RELEASE OF NICKEL POWDER BUILDING K-1037

## PHASE I HAZARD SCREENING

## I. INTRODUCTION AND OBJECTIVES

The Department of Energy (DOE) Order 5481.1B requires that a safety review be performed and safety documentation be prepared for all DOE activities where DOE has assumed responsibility for safety. It has been recognized that existing safety documentation at the Martin Marietta Energy Systems (Energy Systems) facility does not meet current DOE guidance implementing 5481.1B. To address this concern Energy Systems has developed a formal program, in accordance with DOE/OR-901, for the systematic review and update of the existing Safety Analysis Report (SAR) at the K-25 Site. The SAR Update Program (SARUP) consists of the following four phases:

- Phase 0 - Continued Operation Evaluations
- Phase I - Hazard Classification and Qualitative Analysis
- Phase II - Quantitative Accident Analysis
- Phase III - Complete DOE-Approved SARs

As part of the Phase I effort Energy Systems has performed a hazard screening and qualitative analysis for selected facilities. This task is performed utilizing input from the Facility Safety Evaluation Teams (FSET) in the form of the Preliminary Hazard Screening (PHS) Sheets. The facilities that could potentially pose significant safety hazards are qualitatively and/or quantitatively analyzed to determine the extent and severity of the hazards.

This calculation will evaluate the consequences associated with the nickel powder hazard in Building K-1037. Nickel is considered a carcinogen by the Occupational Safety and Health Administration (OSHA) as well as being toxic. The K-1037 Facility was used to produce barrier in multiple parallel production lines for installation in the three gaseous diffusion enrichment plants. The equipment, chemicals and process descriptions are not discussed in the document due to security classification, but can be found in reference 1. K-1037 is located in the eastern part of the K-25 Site between the TSCA incinerator (K-1435) and the steam plant (K-1501). Site Facility Operations and AVLIS Division are responsible for this facility.

The main barrier production area of K-1037 was approximately 60 percent of the building ($\approx$185,000 $ft^2$). Barrier production involved the continuous handling of tonnage quantities of nickel powder. This fine powder was widely dispersed throughout the production area. The production equipment was shut down and placed in standby upon completion of the Process and Equipment Modification program in 1981. Most of the barrier production equipment remains as it was during operation. Sections of the building which could be cleaned of the powder, isolated by sealed partitions and isolated from the central HVAC system are now occupied by personnel.

# II. BASIS FOR DESIGN

## A. Design Input and Source

Information regarding the operation of the facility and the nickel was obtained from the PHS document and facility records.

## B. References

1. CIP CUP Technology, Pt 1 addendum 1, K/GD-500, Confidential.

2. Safety Analysis and Review System, DOE Order 5481.1B, U.S. Department of Energy, Washington, D. C., 1986.

3. Contractor Industrial Hygiene Program, DOE Order 5480.10, U. S. Department of Energy, Washington, D. C., 1985.

4. Hazard Screening Application Guide, CSET-2, 1990.

5. S.R. Hanna, G.A. Briggs, and R.P. Hosker, Jr., Handbook on Atmospheric Diffusion, DOE/TIC-11223, U.S. Department of Energy, Office of Energy Research, Washington, D.C., 1982.

6. Slade, D.H., Meteorology and Atomic Energy, TID-24190, U.S. Atomic Energy Commission, Office of Information Services, Washington, D.C., 1968.

7. Health Effects Assessment Summary Table, OERR 9200.6-303 (91-1) U. S. Environmental Protection Agency, Washington, D. C., January 1991.

8. NIOSH Pocket Guide to Chemical Hazards, U. S. Department of Health and Human Services, June 1990.

9. Internal Correspondence from J. S. Rayside, May 28, 1991.

10. Consequence Determination for a Release of Removable Surface Contamination Phase I Hazard Screening, M-JT285-01-SSE-003, 1992.

11. Microsoft EXCEL, Version 2.1, Microsoft Corporation, Redmond, Washington, 1989.

## C. Assumptions

1. It is assumed that there is approximately 300 lb of nickel uniformly dispersed throughout the surface area of the building.

2. The ceiling height of the facility is 10 ft. Any facility or part of a facility with a ceiling height of more than 10 ft is Bounded by this assumption.

3. To estimate the effects within a facility it is assumed that all of the nickel powder in the facility is instantaneously made airborne and spread uniformly throughout the volume of the facility.

4. The individual inside the facility is assumed to be exposed to the concentration without any respiratory protection for the time it takes to walk out of the facility at a walking speed of 1 m/s.

5. The closest individuals outside the facility are assumed to be on-site within a distance of 100 m.

6. The individual outside the facility is assumed to remain stationary as the cloud passes at the rate of 1 m/s, representing F class stability, but with no mixing or dilution in this range.

7. The region within 100 m of the facility is assumed to have the same concentration as that determined within the facility.

8. The off-site individual is assumed to be located on Blair Road about 275 m from Bldg. K-1037.

9. The breathing rate during the accident for the exposed individual is assumed to be that of moderate exertion ($3.33 \times 10^{-4}$ $m^3/s$).

D. Methods to be Used

1. Dispersion Analysis

The methods of Hazard Screening Application Guide CSET-2, Appendix E, "Consequence Calculation Methodology" will be used to determine the concentration-time integrals and the time-averaged weighted average concentrations for a release of nickel powder from the facility.

The expression for the amount of airborne material for an instantaneous release is:

$$Q = f\,M \tag{1}$$

where Q is the amount of material which becomes airborne, g,
f is the release fraction, and
M is the material available for release, g.

The concentration-time integral and the time-weighted average concentration for an instantaneous release for the close-in estimate are given by

$$I = Q\,t_M/V \tag{2}$$

$$C = I/t_A \text{ if } t_M \le t_A$$

$$= I/t_M \text{ if } t_M > t_A \tag{3}$$

where I is the concentration-time integral, mg s/$m^3$,
V is the mixing volume, $m^3$,
$t_M$ is the exposure time,
C is the time-weighted average concentration, and
$t_A$ is the averaging time, s.

The concentration-time integral and the time-weighted average concentration for the large distance estimate for the instantaneous release are given by

$$I = Q\,(\pi\, u\, A_y\, A_z)^{-1} \qquad (4)$$

$$C = I/t_A \qquad (5)$$

where u is the wind speed, m/s, and
$A_y$ and $A_z$ are the cross-wind horizontal and vertical dispersion coefficients, respectively, m.

The values for the dispersion coefficients in the above expressions are derived from continuous point source values recommended by Briggs for level ground and open-country conditions (Hanna et al. 1982, Table 4.5, p 30). The values are a function of the downwind distance and the atmospheric stability class. There are six stability classes ranging from A (unstable) to F (very stable). For ground level releases the F stability will always yield the highest maximum concentrations and concentration-time integrals, and these values will decrease with increasing distance from the release. Examination of suggested values for instantaneous releases (Slade, 1968, pp 173-175) indicates that a rough approximation for the instantaneous vertical dispersion coefficient is to set it equal to the corresponding continuous value. It also implies that the instantaneous values for the cross-wind, horizontal coefficients are about equal to half the horizontal continuous value. The expressions for the continuous dispersion values for F stability are

$$A_y = (0.04\,x)(1.0 + 0.0001\,x)^{-1/2} \qquad (6)$$

$$A_z = (0.016\,x)(1.0 + 0.0003\,x)^{-1} \qquad (7)$$

where x is the downwind distance in meters.

## 2. Carcinogenic Risk Analysis

Methodology adapted from the Environmental Protection Agency's (EPA) OERR 9200.6-303 (91-1), Health Effects Assessment Summary Table (HEAST), January 1991 (NTIS No.PB91-921199) can be used to determine the increased cancer risk due to exposure to a carcinogen. Quantitative carcinogenic risk assessments are calculated through the use of mathematical extrapolation models to determine cancer slope factors. The following section is quoted from HEAST.

*Cancer slope factors (formerly called cancer potency factors in the Superfund Public Health Evaluation Manual) are estimated through the use of mathematical extrapolation models, most commonly the linearized multistage model, for estimating the largest possible linear slope (within the 95% confidence limit) at low extrapolated doses that is consistent with the data. The slope factor is characterized as an upper-bound estimate, i.e., the true risk to humans, while not identifiable, is not likely to exceed the upper bound estimate and, in fact, may be lower. The quantitative carcinogenic estimates include the following:*

*slope factor = risk per unit dose = risk per mg/kg/day*

*route-specific unit risk for inhalation exposure = risk per concentration unit in air = risk per µg/m³*

*The unit risk estimates for inhalation can be calculated by dividing the appropriate slope factor by the weight of an average person (70 kg or 154 lb) and by multiplying by the inhalation rate (20 $m^3$/day) for risk associated with unit concentration in air. Hence,*

*risk per $\mu g/m^3$ (air) =*
*slope factor (risk per mg/kg/day)(20 $m^3$/day)($10^{-3}$ mg/$\mu$g)/(70 kg)*

*To estimate the risk-specific concentration in air from the unit risk in air as presented in Table B of HEAST, the specified level of risk is divided by the unit risk for air. Hence the air concentration (in $\mu g/m^3$) corresponding to an upper-bound increased lifetime cancer risk of $1 \times 10^{-5}$ is calculated as follows:*

*$\mu g/m^3$ in air = $1 \times 10^{-5}$/unit risk in $(\mu g/m^3)^{-1}$*

This may also be expressed as:

$$C_{lifetime} = R/r \tag{8}$$

where $C_{lifetime}$ is the concentration of the carcinogen in air, $\mu g/m^3$,
R is the lifetime cancer risk, and
r is the unit risk, $(\mu g/m^3)^{-1}$.

Equation (8) provides an estimate for an increased lifetime cancer risk from a continuous lifetime exposure. To adapt this methodology for an increased lifetime cancer risk to the short term accident exposure it is assumed that the health effects are dependent only on the dose received. That is, the total quantity of the carcinogen inhaled during a lifetime is equal to the total quantity of the carcinogen inhaled during a short term accident exposure for a specific risk.

This assumption can be expressed by:

$$D_s = C_L B_L t_L = C_M B_M t_M \tag{9}$$

where $D_s$ is the dose (quantity of carcinogen inhaled), mg,
C is the concentration of the carcinogen in air (i.e., the quantity released divided by some mixing volume), $mg/m^3$,
B is the breathing rate, $m^3/s$, and
t is time, s.

The subscripts L and M refer to lifetime exposure and short term accident exposure, respectively.

From CSET-2 the quantity released divided by some mixing volume (concentration in air) multiplied by the exposure time is equivalent to the concentration-time integral, I. Substituting R/r for $C_L$ [Equation (8)] and I for $C_M t_M$ in Equation (9), simplifying and solving for R yields:

$$R = (I\ r\ B_M)/(B_L\ t_L) \tag{10}$$

The increased cancer risk can now be determined. The average lifetime exposure time and the lifetime breathing rate are given in HEAST as 70 years and 20 $m^3$/day ($2.31 \times 10^{-4}$ $m^3/s$), respectively, and the breathing rate from CSET-2, generally used in hazard screening, is 1.2 $m^3/h$ ($3.33 \times 10^{-4}$ $m^3/s$). The appropriate unit risk can be found in Table B of HEAST, and the concentration-time integral in air for the accident scenario is calculated in the dispersion analysis. The resulting risk can then be compared with the hazard screening approach for characterizing the effects of a carcinogen using a risk level of 0.08 for the boundary between reversible and irreversible health effects and a risk level of 0.008 for the boundary between negligible and reversible health effects (J. S. Rayside's memo, May 28, 1991).

## III. ANALYSIS AND/OR CALCULATIONS

### A. Analysis

The potential effects to persons on-site and off-site are evaluated. Nickel is considered a carcinogen by OSHA as well as being toxic.

To assess the effects within the facility it is assumed that all of the powdered nickel in the facility is instantaneously made airborne and spread uniformly throughout the volume of the building.

For on-site exposure outside of the facility the exposure is calculated for a cloud of the powdered nickel generated as a puff dispersing from the source in the event of a catastrophic failure such as a building collapse.

For the evaluation of close-in receptors outside of the facility the area within 100 m of the facility is considered to have the same concentration as that determined within the facility. The potential effects on persons located within that range are considered to be bounded by the dose received by an individual who remains stationary as the cloud passes at the rate of 1 m/s, representing F class stability, but assuming no mixing or dilution in this range. For the purpose of determining the exposure time the cloud shall be assumed to travel in the same shape as the original building in a direction perpendicular to the building face having the smaller cross section.

### B. Calculations

It has been estimated that there is 300 lb ($1.36 \times 10^5$ g) of powdered nickel in Building K-1037. The building is approximately 820 ft (250 m) long and 400 ft (122 m) wide. The ceiling is assumed to be 10 ft (3.05 m). Thus, the building volume is $9.29 \times 10^4$ m$^3$. The unit risk given in Table B of HEAST is $2.4 \times 10^{-4}$ m$^3$/µg (0.24 m$^3$/mg), and the value used for IDLH is 500 mg/m$^3$ (500 times TLV of 1 mg/m$^3$). Since it is assumed that the powdered nickel in the facility is instantaneously made airborne and spread uniformly throughout the volume of the building, the release fraction is that of a simple powder spill, 0.001.

Tables generated using EXCEL for both the close-in receptor and the distant receptor are presented on the following pages. The first table gives pertinent data for the necessary calculations. The next two tables show the concentration-time integral, the time-weighted average concentration and the cancer risk for the powdered nickel for varying distances. The table for the close-in receptor includes varying exposure times which are dependent on the distance from the receptor to the nearest exit. The exposure time for the receptor within 100 m of the building was assumed to be equal to the length of the building (250 m ÷ 1 m/s = 250 s).

## IV. CONCLUSIONS AND/OR RECOMMENDATIONS

For the close-in estimate (i.e., individuals located inside the facility and individuals located outside the facility within 100 m) the greatest time-weighted average concentration (1.22 mg/m$^3$) and cancer risk (5.74 x $10^{-8}$) were found for an exposure time of 250 s. This is the maximum amount of time that the individual outside the facility would be exposed, and much longer than the individual inside the facility is likely to be exposed. The time-weighted average concentration is well below one-tenth the IDLH value (50 times TLV of 1.0 mg/m$^3$) and the cancer risk is well below 0.008. Therefore, in accordance with CSET-2, the on-site health effects are found to be negligible.

For the off-site individual the greatest effects occurred at 100 m from the facility. The time-weighted average concentration of 14 mg s/m$^3$ is well below one-tenth the IDLH value (50 times TLV of 1.0 mg/m$^3$) and the cancer risk of 2.2 x $10^{-9}$ is well below 0.008. The seeming discrepancy between the time-weighted average concentrations and cancer risks determined for the individuals located at 100 m for the close-in estimate and the off-site estimate is due to air dispersion being considered for off-site and not considered for close-in. In accordance with CSET-2, the health effects for off-site exposure are considered negligible.